SCIENTIFIC AMERICAN

No. SUPPLEMENT 872

Copyright by Munn & Co., 1892.

Scientific American Supplement, Vol. XXXIV. No. 872. Scientific American, established 1845. | NEW YORK, SEPTEMBER 17, 1892. | Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

[From the Engineer.]

THE CAPTAIN OF THE MARY ROSE.

A TALE OF TO-MORROW.

By W. Laird Clowes, Gold Medalist United States Naval Institute.

I.

On the morning of Tuesday, April 28, 189—, the publication in London of the following Reuter's telegram created no small amount of uneasiness and excitement in commercial as well as in political circles. The telegram was dated "Toulon, Monday night," and it was thus worded:

"This afternoon a bluejacket belonging to the British Mediterranean fleet, which arrived here yesterday, got into an altercation in a cafe with a French seaman. Other sailors, British and French, who were present, took sides. The argument assumed the dimensions of a quarrel; blows were freely exchanged; and the British bluejackets were at last driven into the street, and thence to their boats. In the course of the disturbance some revolver and rifle shots were fired, it is belived by the Frenchmen, and unfortunately there seems to have been bloodshed, and possibly loss of life. Owing, however, to the excited attitude of the local population, to the extreme reticence of the police, and to the fact that a military cordon has been drawn round the scene of the outbreak, it is as yet impossible to obtain any trustworthy particulars. The maritime prefect at once went on board the British flagship Victoria. It is supposed that his object was to offer or to ask for explanations; but, upon his return to the shore, no public announcement was made, and nothing definite is therefore known. The situation, without being serious, may at any moment become so. The local authorities are in brisk telegraphic communication with Paris."

This telegram was, in itself, alarming; but the gravity of its import was increased a thousand fold by an announcement which followed it in the columns of the *Times*.

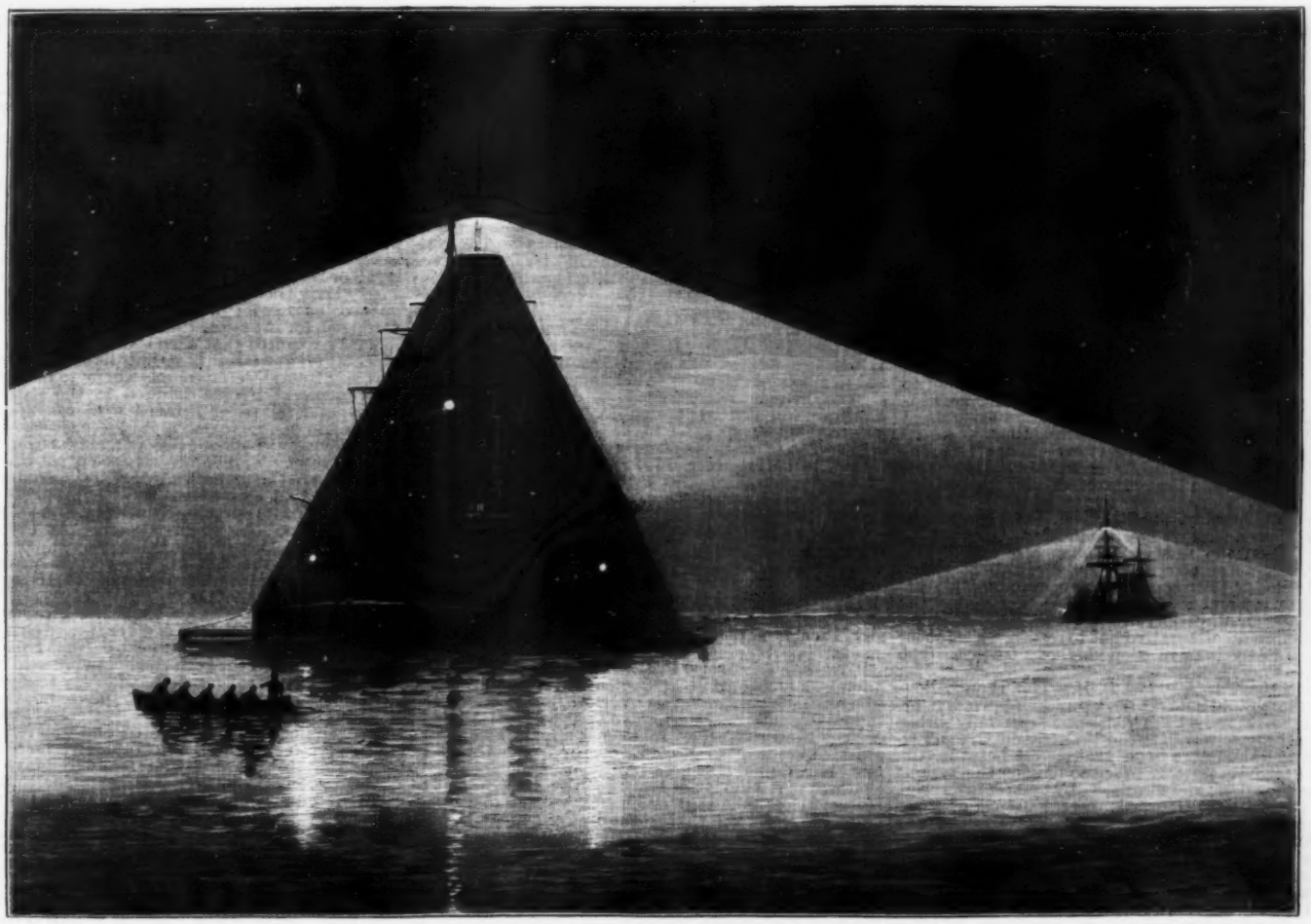
"The above news," said that journal, "is, so far as we can learn, the latest that has been received from France. It reached the *Times* office shortly after eight o'clock last evening. We at once took steps to obtain further particulars. We were, however, informed that between half past seven and half past eight telegraphic communication with France had been totally interrupted, and that all the channel cables, as well as the Irish cable from Havre to Waterville, had ceased to work. There is reason, therefore, to fear that the Toulon affair is of greater importance than Reuter's agent seems to have suspected when he sent off his dispatch. Up to the hour of going to press no further intelligence bearing upon the matter has reached us. We hope, however to receive further news in the course of the night by way of Belgium or Holland, communication with those countries being still open. A copy of Reuter's telegram was, immediately after the arrival of the message, posted up in all the clubs, and exhibited in the windows of several newspaper offices in Fleet street. The news caused much speculation and excitement, and, for the remainder of the evening, formed everywhere the sole topic of conversation. It is a subject for congratulation that Parliament is sitting and that all the ministers are in town. In the Commons, as will be seen on reference to our parliamentary report, the under secretary for foreign affairs rose at nine o'clock, and, apologizing for interrupting the senior member for Northampton, who at the moment was speaking in support of the motion for the appointment of a royal commission on international arbitration, read the telegram to the house, which listened in hushed silence. In reply to several questions the right honorable gentleman stated that he had no further information, and that he trusted that, until further news should be forthcoming, the house and the country would, in deference to the susceptibilities of a friendly power, refrain from demonstrations of any kind. He hoped that the affair would have no serious results; and he had every confidence, he said, that the French government would act in the matter with absolute fairness. In answer to a question as to the alleged interruption of telegraphic communication, he replied that he had no information. At a late hour all the ministers met in informal conclave in the prime minister's room in the House of Lords. They had not separated when we went to press, and nothing, therefore, is known of the upshot of their deliberations. But in the lobbies, and among private members, the fact of the interruption of communications was definitely substantiated soon after ten o'clock, and it naturally excited much alarm. There is very little doubt that the cables have been deliberately cut; though a few sanguine people assert that the non-receipt of further news is due entirely to the effects of the storm which raged during the evening, and which, pitiless as it was, failed to disperse the crowds that thronged the neighborhood of St. Stephen's in anxious expectation of hearing that some additional ministerial announcement had been made. The behavior of the people was strikingly quiet and orderly. Strong feeling was, of course, general, but, for the most part, its exhibition was suppressed. That there were very few noisy demonstrations or patriotic harangues in the streets may, however, be partially attributed to the effect of the rain, which fell in torrents.

"Upon inquiring at midnight at the French Embassy at Albert Gate, we were assured that no information as to the Toulon affair had been officially received.

"For the satisfaction of those who may be ignorant on the subject, we give in the next column the strength of that portion of the Mediterranean fleet which anchored off Toulon on Sunday afternoon. (See table A.)

"The rest of the Mediterranean fleet consists exclusively of unarmored cruisers and light vessels, and is composed of H. M. ships Amphion, Dolphin, Cockatrice, Gannet, Hecla, Imogene, Landrail, Melita, Phaeton, and Sandfly, with one or two stationary vessels. Several are in the Levant or the Red Sea, and none are nearer to Toulon than Malta or Gibraltar. Of the French ships at Toulon we have at present no particular information. We know, however, that there are at least twelve ironclads ready for, or actually in, commission, several powerful cruisers, and a considerable number of torpedo boats, both large and small."

In a leading article on the Toulon affair, the *Times* advised its readers to suspend the formation of opinion until further news should be received; to abstain from any demonstrations which might make worse a state of things that was already sufficiently grave, and loyally to support the government in whatever measures it might deem itself called upon to adopt. Much the same advice was given by all other London morning papers, not one of which, it should be added, contained any more detailed news than appeared in the *Times*.



MASTHEAD ELECTRIC LIGHTS.

* The illustrations are by the Chev. Edouard de Martino and Mr. Fred. T. Jane.

TABLE A.

		Tons.	H. P.	Guns.	Men.
Battleship, 1st class—	Agamemnon	8,600	6,300	6	400
"	Sanspareil	10,470	14,000	15	587
"	Collingwood	9,500	9,570	10	459
"	Colossus	9,420	7,500	9	325
"	Dreadnought	10,820	8,210	4	449
"	Edinburgh	9,420	7,500	9	445
"	Nile	11,940	12,000	10	500
"	Inflexible	11,880	8,010	12	460
"	Thunderer	9,330	7,000	4	400
"	Trafalgar	11,940	12,000	10	500
"	Victoria	10,470	14,000	15	500
Belted cruiser—	Australia	5,600	8,500	12	460
"	Undaunted	5,600	8,500	12	460
Torpedo ram—	Polyphemus	2,640	5,500	—	132
Cruiser, 3d class—	Fearless	1,580	3,300	4	140
"	Scout	1,580	3,350	4	140
Dispatch vessel—	Surprise	1,650	3,400	4	93

And, upon the whole, the advice was faithfully acted upon throughout that Tuesday of anxiety and agitation. A few roughs raised insulting shouts outside the French Embassy, and a truculent individual broke a window there with a stone; but in each case the police promptly interfered, and took the offenders into custody. No more news reached London until shortly before midday; but the early editions of all the evening papers contained the following telegram, which had been received by way of Brussels and the Middelkerke-Ramsgate cable:

"Advices from Toulon report that, shortly after nine o'clock last night, the British Mediterranean fleet, consisting of eleven battleships, two belted cruisers, and four other vessels, quitted its anchorage off that port. A French squadron hastily put to sea at about the same time. The object of these movements is unknown, and in consequence, the most alarming rumors are current. Toulon is in a state of great excitement, and bodies of men patrol the streets singing patriotic songs. Several British bluejackets were killed in yesterday's affray. The authorities refuse to give any information; but it is known here that last evening at a late hour all the submarine cables connecting the British Islands with France were cut by order of the French government. All messages that cross the Franco-Belgian frontier are now jealously scrutinized, and several have been stopped."

During the day, with very brief intervals between them, many still more alarming telegrams poured in. The more important of them are quoted below:

"OSTEND, Tuesday, 12:15 P. M.—The British ambassador to the French republic has suddenly arrived here. Late last night he was roused from his bed and ordered to quit Paris at two hours' notice; and he was subsequently conducted by an armed escort to the Belgian frontier. He leaves at once by special steamer for England. The French Toulon fleet, it is rumored, put to sea yesterday evening, with orders to prevent the British fleet from leaving until full satisfaction should be given for the alleged murders by British sailors during yesterday's riots. It is also rumored that, in defiance of the maritime prefect's order to the contrary, the British admiral has quitted his anchorage. The situation is regarded as most serious; and the dismissal of the ambassador clearly points to a rupture. French troops are being rapidly concentrated at Cherbourg, Brest, Lorient, Dunquerque, and other coast towns; and it is whispered that, as a precautionary measure, a Belgian army corps is to be mobilized and is to occupy the frontier. Numerous British refugees from France have already reached this place."

"DOVER, Tuesday, 12:38 P. M.—The passenger steamer Victoria started this morning as usual for Calais. When she was at a distance of about two miles from the French coast, a French gunboat hailed her and informed her captain that communication between England and France is forbidden, pending the issue of further directions from Paris. The Victoria had therefore no alternative but to return. Two other passenger steamers have been similarly treated. The excitement here is intense."

"BRUSSELS, Tuesday, 1:50 P. M.—The French government last night sent to the admiral at Toulon orders which, if they be acted upon, can only bring about immediate war between France and Great Britain. The orders were to prevent, at all hazards, the British fleet from putting to sea so long as the serious questions which were raised by yesterday's riot should remain unsettled. The exact nature of these questions lies in some obscurity. The prospect of war is said to have already provoked unbounded enthusiasm in Paris."

"FLUSHING, Tuesday, 3:20 P. M.—It is reported that the formal declaration by France of war with Great Britain is only a question of hours; and it is believed that this precipitancy is due to the conviction which is entertained in French government circles that England is just now very ill prepared, particularly in the Mediterranean; and that France, by striking a sudden and unexpected blow, may produce results such as she could scarcely hope to attain if ample time were allowed her adversary for the making of complete preparations."

"PORTSMOUTH, Tuesday, 3:30 P. M.—Orders have just been received here for the immediate commissioning of every ship in harbor that can, by any exertion on the part of the dockyard officials, be made ready for the pennant, and for the hurried preparation of all the rest, not excluding several old vessels that have recently been advertised as 'For Sale,' or even some obsolete gunboats. Similar orders have been telegraphed to each of the naval ports. The dockyard, where, until to-day, work was slacker than it has been since the departure of the ships for last year's naval maneuvers, is already the scene of feverish activity. The coastguard ironclads have been directed to assemble with all haste at Spithead, and not to wait for their full complements, but to leave their respective ports as soon as they can get up steam. Some of them are expected to-morrow. The naval commander-in-chief is now concerting with the general in command of the southern district elaborate measures for the defense, by means of mines, booms, and picket boats, of the port and of the anchorage at Spithead, and to-night the carrying out of their plans will be begun. Masthead electric lights of novel design are being fitted to some of the larger battleships. These are so arranged as to shed a zone of illumination all round the vessel, but to leave the craft herself in comparative darkness, and it is confidently expected that they will be of great value should our squadrons be obliged to anchor at night within raiding distance of the enemy's torpedo boats. Some experienced officers, however, are of opinion that a ship which desires to remain exempt from attack should on no account exhibit a light of this kind, since it must of necessity be visible from a considerable distance to the foe, and they do not hesitate to say that, even if they be supplied with it, they will not use it. The advantage of the light lies in the fact that no ship so long as she employs it can possibly be closely approached by any enemy that does not expose himself to a very dangerous extent. On the other hand, it is pointed out that the apparatus is large, and offers so fine a mark for machine gun fire that it could doubtless be easily extinguished by moderately good gunners at 3,000 yards or even more. Experts here are loud in their regrets that this device, which is quite new, in common with other electric lighting devices which are much older, has not been properly experimented with in peace time, and that, in consequence, no certainty exists as to either its practical utility or its vulnerability. Unfortunately there are symptoms of the existence of a certain degree of friction between the naval and military authorities, nor can this be wondered at when it is remembered by how vague and arbitrary a line their respective functions are divided. The feeling here is strongly to the effect that all the defenses on the sea front should be unreservedly intrusted to the navy and royal marines. On the other hand, there is an undoubted lack of both officers and men even for the manning of the vessels which are to be commissioned. So great, indeed, is the scarcity of stokers, seamen, gunners, and signalmen that only by calling out all the reserves can even the immediate necessities of the situation be supplied. It is not certain, however, that the reserves will be of much use, seeing that the engines of modern men-of-war greatly differ, as a rule, from those of merchant vessels, that few men of the royal naval reserve have any practical familiarity with heavy breech-loading guns, and that hardly any men, outside the service proper, are qualified as signalmen. There is also a scarcity of lieutenants, and a good many small craft will, if commissioned at all, apparently have to be commanded by gunners, carpenters, and boatswains. As for the local permanent defenses, they are very imperfect. Many of the works on the land side have no guns at all, and the re-arming of Southsea Castle and the Spithead forts has not yet been completed. War is here regarded as good as declared. No one, and least of all naval men, can look forward to it with anything like light-heartedness, and many Portsmouth people regard the prospect with distinct apprehension, and propose to leave the town as soon as they can conveniently do so; yet the naval and military population here shows an admirable spirit, and numbers of retired officers of both services are offering their assistance to the government."

"BRUSSELS, Tuesday, 5:8 P. M.—There are grave reports from the south. It is said that a conflict of some nature has actually taken place between the British and French fleets off Toulon, but no details of any kind are given. There is also serious news from Paris. A declaration of war is undoubtedly by this time on its way to London. It was to have been dispatched at noon. The French capital is violently excited, and extremely enthusiastic. Very little news reaches this city, and that little slips through the fingers of very jealous French censors, dozens of whom must be employed along the frontier."

"BARCELONA, Tuesday, 5:20 P. M.—The Italian steamer Monte Pulciano, which arrived here this afternoon, reports that very late last night, when off Toulon, she heard the sound of heavy firing, and saw in the sky the reflections of what seemed to be explosions on a very large scale. She did not, however, call at any French port, and so brings no definite intelligence."

"GENOA, Tuesday, 6 P. M.—The news of difficulties having suddenly arisen at Toulon had scarcely reached this place ere rumors began to arrive to the effect that the French admiral had received orders from Paris to destroy the British fleet in case it should attempt to quit Toulon Roads. No one credited this report at first, but it must now be admitted that corroborative evidence of a kind is not lacking. A correspondent at Hyères telegraphs that much heavy firing took place late last night off that town, but, apparently, at a great distance out at sea, and that to-day some French men-of-war, which seemed to be somewhat damaged, entered Toulon. All messages from France are subjected to strict censorship, in consequence of the strained relations between that country and Great Britain. Too much reliance must not, therefore, be placed upon the trustworthiness of this news."

Then came the most unambiguous telegram of the eventful day.

"DOVER, Tuesday, 6:20 P. M.—A French torpedo boat named the Lance has just entered the harbor under a flag of truce. The lieutenant in command of her brought dispatches which have already been sent on by train to the French Ambassador in London. Their purport is, however, no secret. They contain an announcement to the effect that the British admiral having refused to consider the legitimate demand of the authorities at Toulon for apology and reparation in the matter of yesterday's riot, and having, in defiance of French orders to the contrary, quitted Toulon Roads while the grievances of the French government remained unredressed, the French republic declares war against Great Britain. There is intense excitement. The French lieutenant, who was of course not allowed to land, departed as soon as he communicated with the coastguard boat which went out to meet him. The civil population is apprehensive lest the town may be shelled to-night. Steam is being got up to work the turret on the Admiralty pier; and the men are to sleep beside their guns both there and in the various batteries on the heights.

Stringent measures are to be adopted to preclude all possibility of a *coup de main;* and no vessels will in future be allowed to enter or leave the port until they have been searched. Very few people here are likely to sleep much to-night. Numbers of nervous folk are going inland without even waiting to pack up their effects. A large French man-of-war is now visible in the Strait, but her name is not known. It is hoped that she may be brought to action by the Audacious, from Hull, the Hotspur, from Harwich, or the Iron Duke, from the Forth; for all these ships have been ordered to rendezvous at Spithead, and one or more of them is expected to pass Dover to-night. Here there is not so much as a gunboat; but it is believed that at the latest by Friday some of the coast defense ironclads will be assembled in the Downs, where, in case of need, they will be within easy reach of this most important position. No lights are to be shown to-night, and the windows of even private houses are ordered to be darkened. Pickets are to go round to enforce this rule. The town is already, in fact, though not in name, in a state of siege; and so long as hostilities last, it must be a prey to continual and very harrassing alarms, if to nothing worse."

A later telegram explained that "the large French man-of-war" which had excited Dover was only a steam yacht.

These were not the only telegrams that brought the country to a quick realization of the fearful suddenness with which she had fallen into a state of war with her nearest neighbor and most powerful maritime rival. There were many others, but the effect of all was the same. They startled England, not only with the definite news of imminent hostilities, but also with the vague report, which was far more terrible, that some paralyzing blow had already been dealt against the power which, for three centuries at least, had prided herself upon being mistress of the seas. The nature and result of that mysterious blow were alike unknown; but lack of knowledge, fed by apprehension, often produces strange popular impressions; and the very absence of definite news from the Mediterranean fleet was, at such a juncture, almost by itself sufficient to create very wild alarm.

The excitement in London increased, therefore, as the day wore on. The House met early, but the ministers were able to say little that was encouraging. They were prepared, in case of necessity, to maintain the honor of the sovereign and of the empire; they had adopted such measures as prudence and the counsel of the most experienced officers suggested, and as their immediately available resources rendered possible; and they were, until late in the afternoon, not altogether hopeless that peace might still be preserved; but they had only the most meager information to give; they were unable to inspire the public with that confidence which they professed to feel; and worst of all, they had absolutely no intelligence concerning the Mediterranean fleet save that it had left Toulon on Monday night.

In the afternoon crowds gathered in Trafalgar Square, and other public places; and, in spite of the efforts that were made by the police to disperse the people, addresses—treasonable as well as patriotic—were delivered by persons who, whether they were loyal or not, would in the circumstances have more wisely kept their mouths shut. Most of the theaters opened as usual; and those which opened were thronged, for the temperament of the population at the moment required that men should congregate in any place where the latest news was like to be obtainable. But no attention seemed anywhere to be paid to the performance. People loitered in the passages and foyers, and talked or listened with tongues and ears devoted to one topic only. As the successive editions of the evening papers came out, copies were brought in and handed round, and struggled for even by the musicians in the orchestra. Twenty-four hours previously war had seemed the most improbable of catastrophes. It was practically certain, and what its end might be no one could foretell. At the Lyceum Theater "Macbeth" was being played. Toward the conclusion of the first act the curtain was suddenly lowered, and the familiar figure of Mr. Irving immediately appeared before it.

"Ladies and gentlemen," said the great actor, who was much moved, "news of a very grave character has this moment reached the theater; and I deem it my duty to interrupt the performance in order to communicate it to you. I regret to have to say that, according to a telegram which I hold in my hand, the British fleet in the Mediterranean was yesterday attacked by a French fleet of superior force, and was very severely handled. There are, unfortunately, no details. I trust that the news is not really so grave as it at present sounds; but even if it be untrue that war has actually broken out, and that our brave bluejackets have already been surprised by anything in the remotest degree resembling disaster, I feel that I shall only, in the circumstances, be forestalling your wishes when I announce that the performance cannot continue. Ladies and gentlemen, it is not for me, standing before you in this dress, to say much; but this I must say, the opportunity seems to have arisen for us to show that we are still the sons of our fathers. This, you will agree with me, we may do, not merely by volunteering or otherwise directly contributing toward the defense of our country; but also by lending a steadfast and loyal moral support to her most gracious Majesty's ministers in this moment of terrible anxiety and public danger. England, facing her enemies, has always hitherto been as one man. Let us see to it that she be one man now. Let us banish all divisions; let us think not of ourselves but of our country; and believe me, though the path through this difficulty may be dark and terrible, we shall emerge into the light."

The earlier part of this brief address was listened to almost in silence. The latter part provoked first low expressions of approval and then cheers. When Mr. Irving had concluded, the audience, as with one accord, stood up bareheaded; and, as the orchestra played the first note or two of the national anthem, there began a scene of indescribably contagious enthusiasm. People leaped upon the seats and waved hats or handkerchiefs; women burst into tears; and there was a confused babel of sounds which, in a few moments, blended into the solemn chorus of "God save the Queen."

II.—THE BATTLE OFF TOULON.

What, then, had happened off Toulon?

The *Times* of Wednesday morning was the first newspaper to give anything like a full account of the affair. This it did in the following painful telegram:

"SAN REMO, Tuesday night.—I have just been landed here, thanks to the courtesy of the commander of the Italian dispatch vessel Agostino Barberigo, and, with much grief, I telegraph to inform you of the sudden and terrible disaster which early this morning overtook the Mediterranean Fleet. That fleet, as your readers will see on referring to any of the service papers of last week, consisted of the battleships Agamemnon, Nile, Collingwood, Colossus, Dreadnought, Edinburgh, Thunderer, Inflexible, Sanspareil, Trafalgar—flag of the rear-admiral—and Victoria—flag of the commander-in-chief. On Sunday afternoon these vessels together with the belted cruisers Australia and Undaunted, the armored ram Polyphemus, and the unarmored craft Fearless, Scout and Surprise, anchored off Toulon, and found the French Mediterranean Fleet lying there also. This squadron, which had come in earlier in the day after a cruise, consisted of the battleships Amiral Baudin, Courbet, Devastation, Formidable, Duguesclin, Hoche, Marceau, Vauban, Caiman, Bayard, Neptune, and Indomptable, with the cruisers Cosmao, Troude, and Lalande, the torpedo dispatch vessels Vautour and Condor, and the torpedo gunboats Dragonne, Dague, Aventurier, Kabyle, Audacieux, Ouragan and Temeraire. Up the harbor, in addition, lay the battleships Trident, Colbert, Terrible, Redoubtable, and five other ironclads, all belonging to the 'Escadre de Reserve,' which has been newly constituted. There were also up harbor several cruisers and torpedo vessels.

"We exchanged salutes in the usual way; the admirals called on one another; and yesterday morning about four hundred of our bluejackets were allowed to go ashore. I was at the time on board the Nile, and can give, therefore, only a hearsay account of what occurred in the town.

"It appears that at about four o'clock in the afternoon some of our men, who were drinking in a wine shop, got into an altercation with several French seamen belonging to the Colbert over the merits of the two navies. The Frenchmen boasted that their ships were in every way superior to ours. Jack strongly objected; from words the disputants went to blows; and in less time than it takes to write, our fellows were retreating down the street pursued by a mixed crowd of French soldiers, sailors and civilians. Reports vary as to the damage done, but it is unfortunately certain that at least a dozen of our men lost their lives, and that the French loss was nearly as severe.

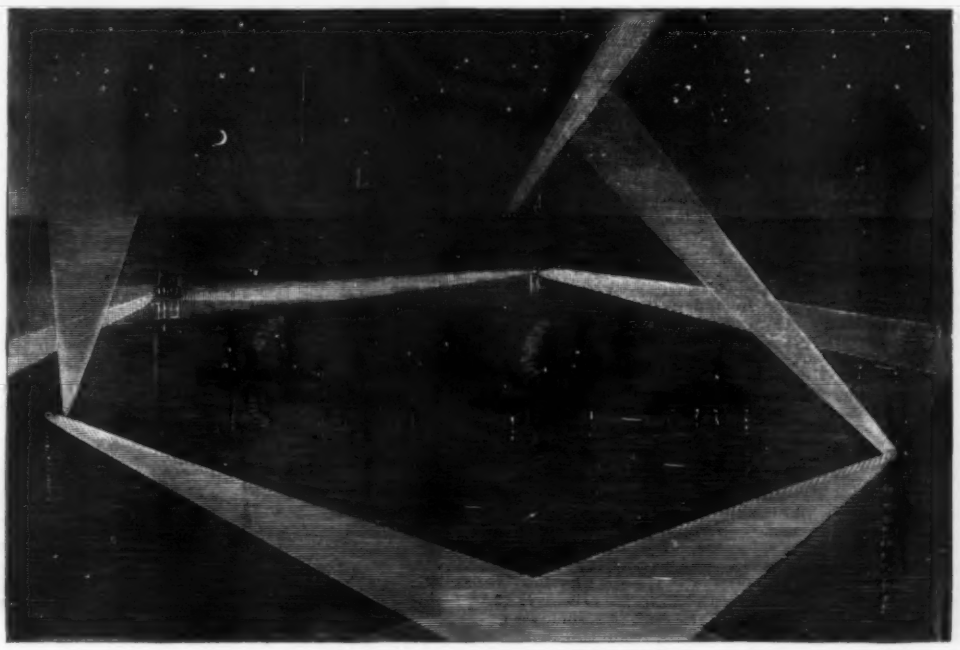
"We, of course, lay too far out to be able to see or hear anything of the hubbub on shore. The first hint of what occurred came to us from the ship's chaplain, who, returning on board in a shore boat, reported that a row was going on in the town. I went up into the top, whence through the glass I could see our men crowding into other shore boats and pushing off in great haste. There was much struggling, and I saw occasional puffs of smoke, which, I knew, could not proceed from our fellows, all of whom were, of course, unarmed. Being closely followed by boats full of Frenchmen, our men made for the Surprise, which lay closer in than the rest of the squadron. By this time the pursuers were using fire arms freely, and we realized that the business was a very serious one. We were therefore ordered to man and arm boats and to cover the retreat. Our fellows pulled like devils, and, with oars and boathooks, fairly sunk one craft which came too close. Those of us who remained on board were all on the bridge or in the top; but just as we were wondering whether we should not have to open fire with our machine guns, we were disappointed by the commander-in-chief semaphoring from the flagship that, bearing in mind the evident gravity of the situation, nothing must be done that might complicate matters.

"This order did not, however, prevent our captain from directing the magazines to be opened, and all preparations to be made that could be made without too pronouncedly attracting the attention of the French. Meanwhile our boats had gained the Surprise, and the men were scrambling on board as fast as they could. A regular swarm of French boats of all kinds were crowding around the ship, and the people in them were screaming and gesticulating as if they were madmen. The commander-in-chief went in his steam launch to the Surprise. Through our glasses we watched his crew shoving the French boats aside, and I doubt whether the shore people would have made room for the launch to get alongside the dispatch vessel if a French officer had not opportunely arrived on the spot in a torpedo boat from up the harbor. When he appeared, the French retired to a respectful distance, but continued vociferating so loudly that we could plainly hear them. The French officer followed our admiral on board the Surprise, and there had an interview with him. Not long afterward they were joined by a stout, gold-laced, red-sashed dignitary from the shore; and the two Frenchmen between them made out, or tried to make out, that our bluejackets had begun the row, had deliberately murdered some men in the wineshop, and, in fine, that they only were to blame. Our admiral, of course, promised to institute the fullest inquiry; but the French officers took a high-handed attitude from the first. They demanded that all of our men who had been ashore should be surrendered. Compliance with this was out of the question. They then said they had telegraphed to Paris for instructions. Before the commander-in-chief got back to the flagship, we saw that most of the French ships in the harbor were getting up steam.

"At a quarter to six all of our captains were ordered on board the admiral. When our captain returned he looked very serious, and sent first for the commander, and then for the fleet engineer and all the lieutenants, most of whom remained with him in his cabin for three-quarters of an hour. The French admiral had promised to dine in the evening on board our flagship, but he sent a somewhat awkward excuse. If I may judge from what I saw in the wardroom in the Nile, where I was a guest, the business spoilt the dinners of every one in both fleets, for all of our people had no end of work to do. We made as many preparations for action as we could without actually going to quarters; we got up steam for full speed; we kept unusually strict watch, and allowed no boats to approach us; and most of us unshipped all the pictures and breakables that we had in our cabins.

"At seven, the Surprise, by order, shifted her berth, and took up a fresh position outside our lines—we were anchored in two columns. The Scout and Polyphemus, under easy steam, went round the fleet and swept their searchlights shoreward continually. To guard against sudden attack by torpedo boats, certain craft were ordered to use their searchlights in combination in such a manner as to form a complete path of brightness around the fleet. The effect was very striking, but it was also very puzzling, for the illumination not only intensified the surrounding darkness, but also rendered it extremely difficult for us to again 'pick up' any craft—and there were several about—after it had once crossed the protected zone; and when half an hour's experience had thoroughly demonstrated this, the experiment was ordered to be discontinued. The eyes of many of us had not, however, recovered from the dazzling results of the trial when, some hours later, we needed our best night sight; and I doubt whether we should not have been wiser had we relied solely throughout upon such natural light as was vouchsafed to us. At a quarter to nine a French steam launch went on board the commander-in-chief, and half an hour later we all knew what it had come out for. It brought a formal demand for the surrender by nine o'clock this morning of every officer and man who had been ashore during the day, and an imperious order that in the meantime no British vessel was to leave the roadstead.

"As soon as the French launch had shoved off again, the commander-in-chief signaled the fleet to weigh. Almost at the same moment the Scout reported that a number of French ships were coming out. They soon began to play their searchlights freely on us, but we went on weighing as before, until one of their flagships, a great ironclad as big as the Trafalgar, but much higher out of the water, was abreast of the Victoria. It seems that the Frenchmen hailed the commander-in-chief, and with great politeness demanded whether he intended to go to sea. Our lights showed us that all the French ships were cleared for action, and were full of men. I suppose that our admiral said 'Yes,' and we half expected, from the threatening attitude of the enemy, that fire would be opened



SEARCH LIGHTS IN COMBINATION.

at once. But the French fleet passed on, and went quietly out in single line ahead, the battleships being between us and their own light craft, which, naturally, kept off, and seemed to be in no regular formation. They were all a mass of lights, and we could plainly see the officers in full dress standing on the bridges and poops, and saluting us as they passed, some of them at a distance of less than a couple of cables from us. As far as I could count, there were sixteen battleships, eight or nine cruisers, and over a dozen torpedo boats.* When they had got well outside of us, they suddenly extinguished all their lights, as if by preconcerted agreement, and ten minutes later another launch from the shore went on board the commander-in-chief. One of our lieutenants was in the flagship at the time for orders, and he told us on his return that the French had sent to say that any further attempt on our part to get away that night would, without hesitation, be prevented by force. Of course we were at once sent to quarters—we had really been at them all the evening, in the Nile at least. It was realized that right or wrong it was impossible, in the circumstances, to obey the dictation of any foreigner. At ten minutes past ten we got under way, and formed in two columns of divisions line ahead, the Victoria, Agamemnon, Edinburgh, Collingwood, Sanspareil, and Inflexible constituting the starboard division in the order named, and the Trafalgar, Nile, Thunderer, Colossus, and Dreadnought the port. The Polyphemus was a mile and a half ahead, the Undaunted an equal distance on the starboard bow, the Australia an equal distance on the port bow, the Scout on the starboard and the Fearless on the port quarter, and the Surprise a mile and a half astern. A rendezvous, which for obvious reasons I suppress, was given us, and the course, as soon as we had made an offing, was southwest. Although a guest on board, I, of course, volunteered to be of what use I could.

"It was an intensely dark night, and there was a nasty sea from the southeast, but very little wind; half a gale, which had been blowing during the afternoon, having dropped at sundown.

"It is not my business—and, indeed, I am still far too fagged and knocked up—to tell you much about our individual feelings and actions. I believe that we were all determined to do our duty, and I venture to think that, in what followed, most of us did it, although for once the luck was against us. You at home must remember, ere you judge us, that we were outnumbered, that several of our heaviest guns were very defective even before the action began, that the speeds of our ships were very unequal, and that, upon the whole, the French vessels were better protected at the water line than ours. I am bound to mention these facts in justice to the hundreds of brave fellows who are gone. It was not their fault that guns broke down or that the fleets were unequally matched. With anything like equal forces, the results of this, the bloodiest naval fight the world has yet seen, would, I am confident, have been different. Surely the blame lies, not with them who had to use the weapons, but rather with those who forged them too weak and too few for the work required of them.

"For three hours we steamed at about ten knots, the slowness of the Agamemnon and Inflexible preventing our easily doing much more, save under great pressure. We saw nothing of the French, and, as we showed no lights, we had much difficulty in keeping station.

"At half past one this morning the Polyphemus flashed a signal to the effect that she had sighted the French fleet about two miles ahead of her, apparently lying to. We therefore altered course six points to the eastward, so as to head south-southeast, and, if possible, avoid the enemy; but I suspect the French must have seen the flashes by which the order was signaled, for, half an hour later, the Scout reported them a mile on her starboard quarter, steaming fast, and apparently coming up with us. We then put on full steam to the utmost capacity of our slowest ships, and again altered course two points to the eastward, so as to bring our heads due southeast; but the fleet, as a whole, could not, it was soon found, do more than 10½ knots against the sea which was running, the Inflexible doing barely that, and lagging behind in the most dangerous way. The Frenchmen, therefore, steadily drew up with us, having altered course soon after we did, and being able to steam fully 11½ knots and perhaps more.

"It must have been inexpressibly galling to our gallant commander-in-chief thus to be obliged to show his heels, even to an enemy of obviously superior force. But it is clear that he could not have remained at Toulon, where he could have accomplished nothing against the forts and batteries; and would, moreover, have been exposed to destruction from mines, submarine boats, and torpedoes worked from the shore, besides having to reckon with the French fleet. It is clear, too, I think, that in the circumstances it was his duty, if possible, to avoid action; though on this point there will probably be great differences of opinion. When once the French were outside of him, he had to think of Malta and Gibraltar, his immediate bases. I must, however, leave these questions for others to discuss.

"At this time I was sent for by the captain, who was on the bridge intently watching the flagship, whose huge hull plowed through the water two cables ahead of us, leaving in her wake a broad strip of foam on the broken waves. The Nile's bows plunged ever and anon into the seas which dashed aft against the turret, well nigh hid the muzzles of the great guns as they burst, and deluged us with spray. We must have had hundreds of tons of water at a time upon the forecastle, but the ship rising shook them off with scarcely an effort, and then plunged again, as the rolling seas lifted her by the stern.

"We had no torpedo boats with us, and, had we had any, they would have been only so many encumbrances in such a sea as was running. Even our biggest boats—the 135 ft. ones—do not steam well in circumstances like those which environed us early this morning, and, unfortunately, we had nothing between them and the regular torpedo cruisers, Scout and Fearless, vessels of 1580 tons displacement. Very useful indeed to the commander-in-chief would have been a few fast gun vessels of the Grasshopper or Sharpshooter class, not so big as to be easily visible,

* For the exact composition of the French fleet, *vide* the statement at the end of this chapter.

yet big enough to stand the knocking about and still preserve a decent speed of 15 or 16 knots. Alas! We had nothing of the kind, the Landrail and Sandfly being detached. The French, on the other hand, were well provided in this respect. They had with them several large torpedo boats, *torpilleurs de haute mer*, of the Bombe class, which served them in particularly good stead as scouts, and which, being craft of over 300 tons displacement, could breast the sea. With these, as we speedily found, they were able to creep up and observe us, without being sighted until they were close upon us. We, therefore, had an uneasy feeling that we were all the time being watched by spies which remained almost invisible.

"Finding at last that it was hopeless to think of getting rid of the foe by outsteaming him, the admiral, the French being now reported broad on the Inflexible's starboard quarter, at a distance of between two and three miles, decided to attack. He, therefore, in accordance with a previously concerted arrangement, led his division ahead of the other one, so placing himself in the van of a long single column disposed in line ahead, and having completed this change of formation, ordered the battleships to alter course in succession ten points to starboard, and the cruisers to obey previous instructions, which seem to have run to the effect that they were to be as useful as possible, and to be ready to tow the ironclads, but not to needlessly imperil themselves.

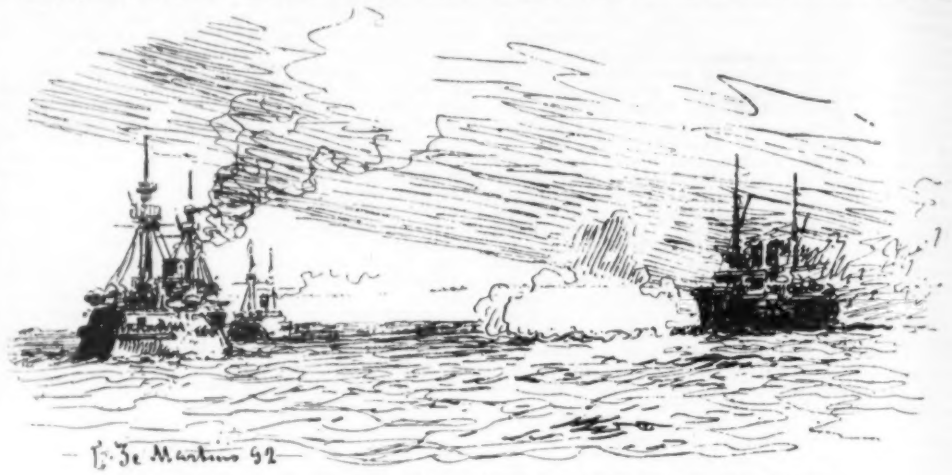
"It looked at first as if we were going to engage the enemy in the old fashioned manner, for the French were steaming in a direction nearly at right angles with our line, and in single column; but they very speedily altered formation, so as to bring themselves into a line abreast in groups of three. In this formation the two fleets neared one another, the Trafalgar leading, we coming next, and after us in succession coming the Thunderer, Colossus, Dreadnought, Victoria, Agamemnon, Edinburgh, Collingwood, Sans-pareil, and Inflexible.

"It was about half past two o'clock. Suddenly a ship near the center of the French line began to use her search lights on us, and fired a blank charge. Immediately all the other vessels did the same, and we soon followed suit, not, however, firing. Both sides seemed to feel that to engage in darkness would be doubly dangerous; but, in truth, the electric lights served only to render the situation more puzzling. The effect of the light when it shines into the eyes of the spectator is confusing in the extreme. It is absolutely impossible to decide, or even to guess, how far off the projector, whence the beam comes, is; and when the glare permits of surrounding objects being seen at all, it seems generally to show them distorted or misplaced. Moreover, in certain conditions of atmosphere, dependent, no doubt, upon the amount of moisture in the air, the beam, instead of being translucent, has the effect of a dazzling and semi-opaque white screen. Upon it, in these circumstances, shadows can even be cast, and phenomena resembling the mirage or the 'Brocken specter' may be produced. I remember hearing Sir Nowell Salmon years ago tell how once in his steam launch he actually went in chase of one of these apparitions, and how he only discovered that he was pursuing his own shadow when he had occasion to shake his fist at the artificer in charge for not getting more speed out of the boat. I mention this solely because I am sure that more harm than good is, as a general rule, likely to be done during night actions by the use of the search light. A moment later the French opened a perfectly awful fire on us, apparently from every gun that would bear. It seemed as if the whole horizon had become a mass of ragged smoke and belching flame. Only a very few of our men happened to be on deck, but nearly all these were killed or wounded. The captain himself, who was still on the bridge, was wounded in the right leg, but he refused to go below. We got him into the conning tower, however, without further injury, and I remained at his side until the end, the enemy's fire continuing without intermission from the moment when it first began until the action was over.

"The wind being so light as to scarcely stir the air, and that little coming now from the northwest, such smoke as did not hang rolled gently down the French line, and shrouded from us the greater part of it. Almost immediately ahead of us was a group of three French ships, which I took to be the Formidable, Hoche, and Marceau. As the admiral neared them he swerved slightly to port and went straight for the Formidable, while we swerved to the same extent to starboard and headed for what I believe was the Marceau. We thus put ourselves to windward of the flagship, and the smoke of her guns, as she opened fire, hid her from us. But I could see our immediate opponent quite plainly, a great towering single-funneled three-masted ironclad, with a central battery, lofty sponsons, and a high forecastle. At less than a cable's distance we got one shell from our left fore turret gun fairly into her starboard bow, where it burst, wrecking all the fore part of her. At almost the same instant, however, something struck our conning tower and caused nearly everything in it to fly, so depriving us of our communication with the people at the guns, except by means of the voice tubes, which still held, but which were in the din nearly useless. There were only the captain, the staff-commander, myself and two signalmen in the confined little box, from which of course no one could be spared, and which for the moment was practically cut off from the rest of the ship. The six-inch guns in our starboard battery fired once; but in vain did we shout down the voice tubes for them to continue, although we were now almost brushing the paint off the Frenchman's side as she just managed to escape our ram, and although we might, had we given her a broadside from our guns well depressed, have blown her bottom out. In the meantime she was treating us terribly; and it was not until we had passed through the enemy and well beyond him that it was possible for us to send a man below to convey orders and to report upon what had happened.

"The news that came up soon afterward was even worse than I had feared to learn. The whole starboard side of the box battery was beaten in, two of the guns in it were dismounted, and every man in the battery had been killed or wounded. The hydraulic loading apparatus of one of the guns in the fore turret had broken down and the gun was useless; the funnels were so knocked to pieces as to seriously reduce our steaming power, two 5½ in. projectiles had hit us and pierced us below the waterline, and two of our compartments were flooded. There were many other damages, the details of which were not reported; and there was no time, of course, for full inquiry.

"The captain in spite of his injuries was still able to retain command, and he had after clearing the French line brought the ship round sixteen points to port, in order to renew the action with the Marceau; or, in case we could not discover her, to engage some other ship. But scarcely had we turned ere we were attacked by two of the *torpilleurs de haute mer*, to which I have already alluded, as well as by several torpedo boats of a smaller type. Ahead of us the battle was raging, and the night was lurid with flash and explosion; but abreast and astern of us all was darkness, and out of this darkness our little foes dashed upon us suddenly from all directions. At the first onset, as I have explained, our men had been driven from the quick-firing and machine guns on the upper deck by the enemy's terrible fire. Many of these guns had been dismounted or injured; and the torpedo boats came on while those guns which had escaped were being again manned. For a few seconds, in consequence, we had nothing with which to meet the attack, and in the meantime the enemy was blazing away at us from his 3-pounders and machine guns. We tried to use our searchlights once more, but we could not get them to work, probably because the cables had been destroyed. We did, however, succeed in opening fire to a limited extent before the enemy got very close, and, I believe, we sunk one of the small boats. But, although the men be-



'SUDDENLY A SHIP NEAR THE CENTER OF THE FRENCH LINE."

"THE EFFECT OF THE LIGHT WHEN IT SHINES IN THE EYES OF THE SPECTATOR IS CONFUSING."

"IT IS IMPOSSIBLE TO GUESS HOW FAR OFF THE PROJECTOR IS."

TABLE B.

French Fleet Engaged in the Action of April 27–28.

	Tons.	H. P.	Guns.	Men.
Battleship—				
Amiral Baudin	11,380	8,320	15	500
Courbet	9,652	8,112	14	670
Devastation	9,639	8,154	14	685
Formidable	11,441	9,700	15	500
Hoche	10,650	11,300	20	660
Marceau	10,581	12,000	21	660
Amiral Duperre	10,487	8,120	19	664
Caiman	7,200	6,000	6	332
Friedland	8,824	4,428	16	675
Indomptable	7,168	6,605	6	332
Richelieu	8,767	4,240	19	720
Trident	8,456	5,083	16	730
Colbert	8,457	4,652	16	706
Terrible	7,713	6,230	6	332
Redoubtable	8,857	6,071	14	700
Vauban	6,150	4,561	11	440
Bayard	5,986	4,538	12	450
Cruiser—				
Cosmao	1,877	6,000	4	150
Troude	1,877	6,000	4	150
Lalande	1,877	6,000	4	150
Sfax	4,502	6,522	16	473
Jean Bart	4,122	8,000	10	360
Cecille	5,766	9,600	16	486
Faucon	1,240	3,233	3	134
Vautour	1,280	3,391	5	134
Condor	1,240	3,582	5	134
Wattignies	1,310	4,000	5	140
Torpedo gun vessels—				
Dragonne	395	2,000	Q F.	63
Dague	395	2,000	"	63
Leger	450	2,200	"	63
Bombe	395	2,000	"	63
Levrier	450	2,200	"	63

And the first-class torpedo boats Ayela, Audacieux, Coureur, Ouragany, Temeraire, Kabyle, Orage, Aventurier, and Eclair.

haved splendidly, and worked at the guns with admirable steadiness, the game was up. A torpedo hit us on the port bow, just under the forward sponson; and in an instant, or rather as soon as we realized what had happened, we knew that the dear old Nile was done for. The shock was tremendous, and threw us all down, for the ship's bows rose violently into the air and trembled as if they had been wrenched and twisted by some angry giant. But bruised and bloody as we were, we were soon up again. The entrance to the conning tower was half blocked with the *debris* of boats and booms, yet the captain, in spite of his wound, managed to struggle out on deck, and I followed. Several boats were by this time almost alongside, and as we appeared, a French lieutenant in one of them coolly removed his hat, and made a motion as if to ask whether we surrendered. The captain fired his revolver at the gallant fellow, and, even as he did so, fell back, shot through the chest by a bullet from a machine gun. 'Don't haul it down while we float,' he cried, as he lay writhing in his last brief agony: 'Remember what they will say at home.'

"We did not haul it down. We drove the boats off, and gave them a weak cheer as they went, but the ship was at that time settling rapidly down by the head, with a frightful heel to port. The boats were ordered to be got out. They were, however, all knocked to pieces. We did our best also to steam back into the still battling fleets, feeling that no fate could be much worse than the one which immediately threatened us; but the water had got into the stokeholds, owing, I suspect, to some of the bulkheads having given way under the pressure, and we could not move. Just when everything seemed most hopeless I saw what looked like a small cruiser rapidly making for us, with all her lights showing. But she came too late for most of us. While she was still a full mile away the Nile's stern rose high out of the water, so high as to send everything and everybody on deck adrift, and then, with a great gurgle, the ship dived down bows first.

"I have no further recollection that helps me to explain how, when the day was beginning to dawn, I found myself clinging to a splintered grating, alone upon the sea. I was dizzy and chill and sore from head to foot, and I was almost naked, but I clung on mechanically. Indeed, my arms were so stiff that it seemed that I could scarcely have unclasped them, even if I had wished to do so. As the sun rose I caught sight of a vessel under steam, less than half a mile from me; and although I was able to make no effort to attract attention, I was in another quarter of an hour so fortunate as to be picked up by a boat which was sent for me by the commander of the Agostino Barberigo, and to be taken on board by the kindly Italians. They tell me that at first I could give no account of myself, and that I could neither speak nor stand, but they treated me so well that by midday I recovered.

"My first question was, naturally, about the fleet. Terrible, even beyond my apprehension, is the fragmentary story which my rescuers told me. The Agostino Barberigo had been almost within gunshot during the action, which had lasted for less than an hour. After the battle her commander had hailed the French ironclad Amiral Baudin, and had learnt that, of our ten battleships, five—namely, the Nile, Agamemnon, Edinburgh, Inflexible, and Collingwood—had been either sunk or compelled to strike, and that of the remainder, two at least, although they had temporarily got away, were entirely disabled. One of these was understood to be the Victoria, in which quite early in the engagement there had, apparently, been some serious accident. The fate of the Polyphemus was unknown, but she had rammed or torpedoed and sunk the Trident. The Australia had got away, but the Undaunted, toward the end of the action, had made a gallant endeavor to ram the Vauban, and although she had considerably damaged her, had been sunk, firing as she went down. The Surprise had got away, but was on fire when last seen. The Fearless, after colliding with one of our own vessels and having her bows stove in, had been taken. The Scout had rammed and sunk the cruiser Sfax, but had herself gone down, though I am glad to be able to add that most of her officers and crew are safe on board the cruiser Cecille. Finally, in addition to the Trident and Sfax, the French are said to have lost the Vautour cruiser and the Kabyle—*torpilleur de haute mer*—as well as two small torpedo boats.

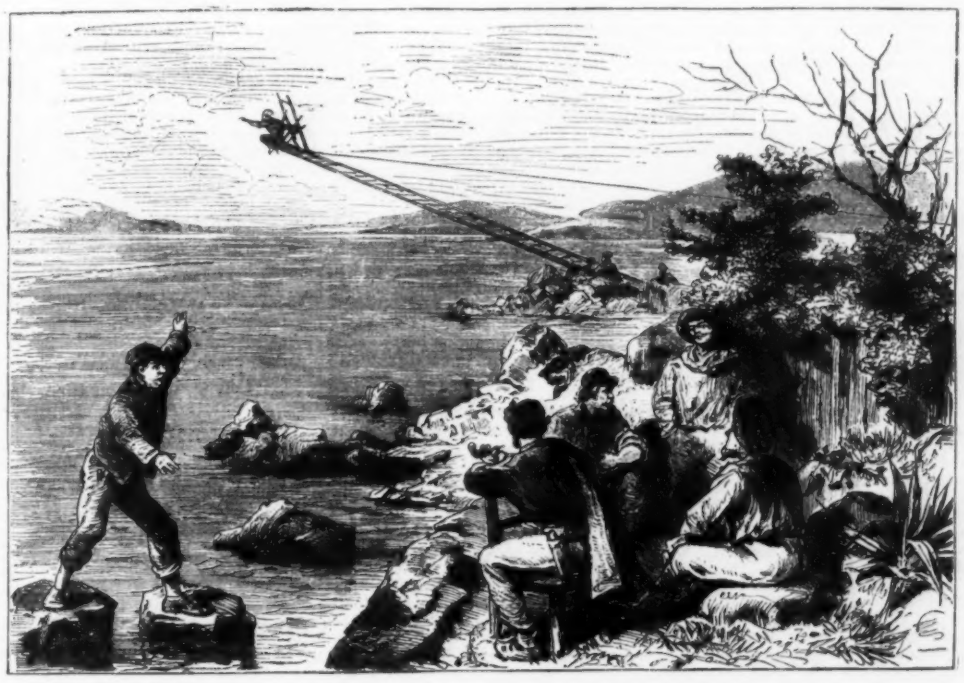
"But the victory, which is an undoubted one, lies with them. Our Mediterranean fleet, as such, exists no longer. Half of it has been destroyed or taken; the other half is disabled, and in all probability scattered. Never before in all her history has England experienced so complete a disaster upon the sea, and it can be but slight satisfaction to us to know that to purchase this grand success our enemies have spent an old second-class ironclad, a large but not very new cruiser, and three or four small craft, even when we know also that many of their other vessels must be severely damaged.

"When I was picked up, I was nearly ten miles from the scene of the action; and so far as I know, I am the only one of my ship's company that has escaped, though one cannot but trust that others were picked up by the cruiser which was approaching us when we went down. The Agostino Barberigo had, however, on board about thirty bluejackets and a wounded sub-lieutenant, whom she saved when the Agamemnon sank; and it is certain that in the French fleet, the greater part of which put back to Toulon, there are many other survivors.

"I can add no more. As a British officer who as a volunteer has tried to do his duty I cannot, nevertheless, avoid expressing the opinion that if we had had a proper Mediterranean fleet—one equal or superior to that of the French—this grievous disaster would not have occurred. We allowed ourselves to be lulled to sleep by the peaceful aspect of affairs here; and the unforeseen storm has found us unprepared to cope with it. Such fleet as we had was weak, not only numerically, but also in armor and armament; for enormous guns and partial belts have proved a failure. We have been pinning our faith too much to these partial waterline belts and to guns of monstrous proportions. The only one of the Sanspareil's big guns that was fired broke down. The other could not, for some reasons which I have not been able to discover, be fired at all. And I am informed, by a seaman who belongs to the Victoria, but who had been lent as a signalman to the Agamemnon, that the accident already alluded to as having occurred in the Victoria was, in fact, the bursting of a 110 ton gun in her turret. If I can, ere I start for home, learn any further details of our unexampled misfortune, I will lose no time in telegraphing them. I am aware that this account leaves much to be desired. The awful circumstances in which it is written must be my excuse. The fact that I have, in a short hour, lost, as I cannot but believe, most of my shipmates and dearest friends, gives me personally such poignant pain that I can barely concentrate my thoughts; but even more am I overwhelmed by the consciousness of the irreparable loss in officers and material that has fallen upon the country. Would that half the gallant fellows who perished to-day were still at the call of England; for sorely will she need them."

Thus the bolt fell from a clear sky, and within a few hours the two most powerful naval nations of the world found themselves engaged in deadly struggle.

Elsewhere in its issue of the Black Wednesday, the *Times* gave particulars (see Table B), derived from other sources, of the victorious French fleet. It also mentioned, in a leading article, that the telegraphic dispatch above quoted had been sent to it by Lieutenant Thomas Bowling, R.N., an officer on half pay, who had been present as a guest in the ill-fated Nile. And in its later edition it contained a great deal of bad news from a spot far less distant than the Mediterranean.



TUNNY FISHING ON THE MEDITERRANEAN.

TUNNY FISHING ON THE MEDITERRANEAN.

THE tunny (*Thynnes vulgaris*) is caught along the Adriatic coast, near Abbazo (Istria, Austria), during the end of April and the first part of May. At this time the tunnies, which attain a length of from 8 to 12 ft., and weigh up to 1,200 pounds, leave their submarine hiding places in the bottom of the Mediterranean, and travel in large shoals toward the coast for breeding in the sea weed. Before the arrival of the fish, the shores are crowded by fishermen and spectators, and a watchman is perched on the outer end of a ladder-like frame, which extends from the coast far out into the ocean, as shown in the accompanying engraving taken from the *Illustrirte Zeitung*. The watchman on this tower can readily detect the coming of the fish by their striking against nets and causing a disturbance on the water. The nets are set in such a manner as to form labyrinthic chambers extending from the coast about a mile out into the ocean. As soon as the watchman discovers the approach of the fish, he gives the signal to those on shore, and a general rush is then made for the boats, which are rowed out rapidly to the sea, to assist in driving the approaching shoal into the nets.

The fish pass through the various chambers formed by the nets, until they finally pass through the second last one, called the golden chamber, which has but one exit, leading into the death chamber. As soon as the manager in charge finds that a sufficient number of fish have entered the last chamber, then he gives a signal to draw in the outer nets from the sea and shore to close the outermost chambers, to prevent the fish from escaping to sea. The fish are then killed in the death chamber by means of iron-clad clubs, wielded by the fishermen. During a season the above is repeated from about ten to fifteen times at one and the same place, and as many as 600 fish have been caught in one season.

The tunnies have appeared along the Italian, Austrian, and Tunisian coasts for about the last 130 years, but are now rather rare along the Spanish coast, which is attributed to the earthquake of 1755, at which time a sinking of the Spanish coast took place, and the fish were driven away.

A large number of such watch towers, illustrated in the accompanying engraving, are erected along the Istrian coast from Abbazo along the coast road leading to Volosca. As is well known, the flesh of the tunny resembles veal, is delicate, and has been in demand from time immemorial. T. G. H.

[FROM THE N. Y. SUN.]

THE SCIENCE OF FISHES.

By J. S. KINGSLEY.

EVERY year, when the weather becomes warm, and the annual pilgrimage begins to the summer resorts, students from all parts of the country, from California and Dakota and the Carolinas, turn toward Wood's Holl to study in the well-equipped Marine Biological Laboratory there. This place is admirably adapted for its purposes by nature as well as by its buildings and equipment. No richer spot for collecting exists on the whole Atlantic coast, while the student can have his summer relaxation here at the same time that he is adding to his store of knowledge. The south winds, which elsewhere are so hot, come to the south shore of Massachusetts straight from the Atlantic, and are consequently cool and refreshing. On the other hand, the water itself is warm, so that here, as at Newport, one can bathe without that shock which so frequently occurs in the colder waters north of Cape Cod.

There are two large laboratories at Wood's Holl. One of them, the United States Fish Commission, is the property of the general government. Here, during the summer, students are at work upon the various problems directly or indirectly connected with the supply of food fishes. In the winter the students are mostly gone, but the commission is not idle. Its energies are now turned to the hatching of cod and lobsters and other food fishes. The eggs are obtained by millions, and are placed in ingeniously arranged hatching jars, so that they are under the most favorable conditions. Then, when the young are able to shift for themselves, they are turned loose in the sea to grow and fatten, and perchance to be caught for food.

The fish commission is a government institution, and to study there one must have an invitation from the

commissioner; the other Wood's Holl station, the Marine Biological Laboratory, is open to all upon payment of the proper fees. The fish commission is chiefly for the solution of economic questions connected with food fishes; the Marine Biological Laboratory is devoted to pure science.

The building of the Marine Biological Laboratory is simple and without any architectural pretensions. A rectangular two-story building about 30 by × 60 feet, with an L, 20 × 40, can be made severely plain, and yet this shingled structure in one way exhibits true architectural merit, in that it is well adapted for its purposes. At the first sight one is struck by the size and number of the windows; and, considering the nature of the work done, there is none too much light. The main entrance leads directly into the lower laboratory, which occupies nearly the whole of the ground floor. Along either side of this large room are arranged large laboratory tables, each accommodating four students, while in the center of the room is another table with the aquaria, always of interest to the visitors.

The animals in these aquaria are changed almost daily. This change is not intentional, but follows from the nature of the work done. These tanks serve as reservoirs for the animals studied, and as the students are working—now on lobsters, now at starfishes, and again upon clams—the stock on hand must vary. Then, again, any strange or unusual form taken is placed here on exhibition, so that one day may be seen here sticks covered with goose barnacles, each one, as Huxley expresses it, kicking its food into its mouth with its feet; another day there are numerous squid, with their constantly changing hues, darting hither and thither by their peculiar force pump propeller. One year the tanks contained almost constantly one or more of the beautiful Portuguese men-of-war, the float colored red and blue, while below the green tentacles are in constant motion. But beware of these beautiful streamers, for where they touch the skin they raise a bright red ridge which smarts as if burned.

The students in this lower laboratory are elementary workers. Some are college students, doing extra work in vacation time; some are teachers in high schools, while not infrequently dignified college professors have been glad to come here and obtain instruction. The non-scientific reader may be interested in the way in which they study.

Each morning there is a lecture in the adjacent lecture room by some one of the teaching force. This may be either a somewhat detailed account of the structure of some animal or plant, to be studied later by each student in the laboratory, or it may be an account of the relatives and relationship of some form already studied, for knowledge gained here is to be valued accordingly as it is comparative.

After the lecture, which is usually about an hour long, the students return to the laboratory and begin the day's work. Suppose it be some large animal like a lobster which is to be studied. It is first examined from every side. Its legs are pulled off and studied, then the jaws are compared with the legs, and then the feelers with both legs and jaws, and from these the instructors strive to lead the students to work out for themselves the laws of structure upon which a lobster is formed.

When the outside has been mastered, the internal organs are studied. The way the muscles act, the peculiar grinding mill in the stomach, the brain and the nerves are all investigated with the scalpel. When the heart and blood vessels are taken up, the student is shown how to fill them with starch and vermilion, so that the finest tubes can be traced by their bright red color into every part of the body. In the same way star fishes and sea urchins, clams and oysters, sharks and the like are dissected and studied.

In all this work the student is made to draw, more or less artistically, all the parts seen, for it is a well-known fact that when a person has to draw exactly what he sees, he will see far more than he otherwise would, especially when the accuracy of the drawing may be questioned later by the instructor.

When the animals are small, simple dissection is no longer sufficient, and the compound microscope is necessary. With these the laboratory is well equipped, the instruments being made by the best makers. If the animal be transparent, all that is necessary is to place it in a watch crystal of salt water under the microscope, when the principal points of structure are readily seen; but if, as is frequently the case, the animal be opaque, the study is complicated.

This is the way the difficulty is got around. The animal is killed properly by certain chemicals and hardened by others, and is next imbedded in a block of paraffine so that the object lies like the wick in a candle. All this is necessary because fresh tissue cannot be easily cut. Now it can be cut with a razor into slices of extreme thinness. To aid in this "section cutting" instruments known as microtomes have been invented, and, provided the knife is sufficiently sharp, sections a fifteen-thousandth of an inch thick can be made, but usually about one two-thousandth of an inch is sufficient. These sections or slices are placed on a bit of glass, the surrounding paraffine is washed away with turpentine, and the sections are then studied with the compound microscope.

The upper floor of the laboratory is devoted to the more advanced workers. Some of these are persons of national reputation, who are here passing the summer in deeper study into the secrets of nature; others are just beginning the work of original investigation, and have not acquired the ability of going alone. These latter are in part graduates of the lower laboratory; in part those who have done equivalent work elsewhere. They need constant attention and advice. Think for a moment, you who have never worked in a biological laboratory, of how you would go to work to find out something new. What would you take up? How would you work at it? And how would you recognize a new fact when you had found it? This portion of the laboratory aims to supply just this training, and that such training is needed is amply shown by many of our scientific journals.

Twenty of these students can be accommodated in the large rooms of the upper floor, and each one is as much under the charge of the instructors on that floor as are the beginners down stairs. Each one on entering the laboratory has his work mapped out for him. The problem is assigned, the methods of study suggested, and with constant assistance and advice the student is led to find out the facts in the case. The instructor has also to show the beginner how to use the literature and how to find out whether his facts are new, and also what their bearings may be. In this assignment of work good judgment must be exercised to pick out problems within the power of the student, and also those which will return adequate results, both in new facts and in training as well.

Leading from the main laboratory are twenty-four private rooms, each equipped with its own aquarium, glassware, china, cuts, etc., where the investigators who no longer need instruction can carry on their studies undisturbed by outsiders, and, if necessary, in secrecy. It not infrequently happens that two workers have attacked essentially similar problems, and thus, of course, there is naturally considerable rivalry, and each wishes, until ready for publication, to keep his results from the others.

If it were possible to describe in detail the work done by the investigators, the account would prove exceedingly dry to the layman. An example, however, may be outlined to serve for all.

Only a few years ago most students were engaged in describing new species or in studying the structure of those already described. Now, one great problem is, How does that structure arise? So at Wood's Holl the tracing of the changes from the egg to the adult naturally occupies a prominent place. Each animal has its own peculiarities of development, and so only a general outline can be given, in which only the salient features can be touched upon.

The student obtains the animals whose history he wishes to trace and from them obtains the eggs and milt. These are mixed together, and from this moment every instant of the history is of interest. Most of the eggs studied are greatly different in general appearance from the familiar egg of the hen. They are usually small, frequently microscopic in size, while many of them are perfectly transparent. In this latter case certain features of development are studied with comparative ease, for, placed beneath the microscope, most of the internal changes can be readily seen. In other eggs which are perfectly opaque only the modifications of the external surface can thus be seen, and for internal structure the same process of section cutting described above must be resorted to.

The typical egg we are describing is a mere sphere of that much talked about and yet little understood substance, protoplasm. After it is fertilized it divides into halves, and each half into quarters, and so on, again and again, until the egg is converted into a ball of small spheres or cells, the whole much resembling a blackberry in its general appearance. Then these cells become arranged into layers, an outer which is to grow into skin and nervous system, an inner which will make stomach, etc., and a middle layer, to be later differentiated into muscles, blood, blood vessels, fat, etc., and, in the case of vertebrates, into bone and cartilage.

As has already been said, in this embryological study section cutting plays an important part, and the work soon acquires great facility in all its many steps. It is not a difficult task to cut an egg one one-hundredth of an inch in diameter into fifty or a hundred sections and have these sections pass through the egg in any desired manner. Plain sections show but little under the microscope, but the naturalist has found out that the different portions of every animal and every plant differ considerably in their chemical constitution, so that if placed in certain staining fluids one part will be colored while another will not. Thus solutions of carmine and logwood will render visible in each of the little balls or cells of the egg described above a part which stains more deeply than the rest.

This is called the nucleus, and the more it is studied the more important does it appear to be. It is apparently the bearer of all hereditary tendencies. Again, solutions of gold properly used stain nerves bright purple, so that the students can trace their finest terminations; ozonic acid blackens fat, and blue de Lyon renders the most minute bit of bony tissue bright blue. So, naturally, this staining plays a most important part in investigation.

For much of the material used the students do their own collecting. This gives them an outing and also serves to teach them something of the habits of marine animals. The laboratory has rowboats, sailboats and a fine steam launch. The latter is in daily use, conveying students to Maushon and the other islands of the Elizabeth group, dredging in Vineyard Sound, or visiting the fish ponds scattered along Buzzard's Bay.

Dredging is an interesting operation, for it always is more or less of a lottery. The launch steams out into the sound until it reaches some point which seems favorable, and then the dredge is put down. This is a rectangular iron frame with sharp edges to scrape the bottom and a bag behind to catch everything that is scraped up. When the dredge is down the launch steams along slowly, and after a short time it is drawn to the surface and the contents of the bag poured into sieves, and after washing away the mud, etc., the remainder is carefully picked over and the treasures either immediately preserved or taken back to the aquaria in the laboratory. Usually the dredge will contain a considerable variety of forms, but occasionally a haul will show only one or two species.

The daily life of the students is easily described. They find rooms with the various families in the village, while the laboratory runs a mess hall, where all obtain their meals. The laboratory is open daily from 7 or 8 in the morning until 10 or later at night.

The general outline of the work has been given, and there are but few things to interrupt it. Among these is the daily service by most of the students, and besides there are given once or twice a week a course of evening lectures by the teaching force of the laboratory, or by some visiting naturalist who chances to be present. These lectures are highly regarded, and rightly so, for nowhere else in America has ever been given a course of scientific lectures by such masters as here.

The statistics of the laboratory are here summed together. It is a national rather than a local institution, as is seen by the distribution of its students. In the four years that the laboratory has been open 135 workers have been present, coming from twenty-three States, from Canada and Japan. The laboratory is rapidly growing. The first year it accommodated seventeen, last year seventy-one workers. This year an addition to the building has been made as large as the original structure. It depends for its support upon the fees of the students, upon the interest of a very small endowment, and upon the subscriptions of friends interested in science. The fees are, for the elementary department, $30; for the investigation department, $50, for the season. The teaching force do their work largely as a labor of love. They are mostly professors and teachers in colleges and universities, who, while their colleagues are enjoying a vacation, are continuing here the same instruction that they have been engaged in for the whole year.

Such is the Marine Biological Laboratory to-day. The laboratory of the future, so its friends think, will be a well endowed station for research, which will be open winter and summer with its regular corps of investigators, with every facility for investigation and publication, in short, a station second to none in the world. For such the beginning has already been made. Land is already bought and the foundation of the endowment laid.

In closing, a word must be said to those to whom the laboratory owes its present shape and progress. Without making invidious distinctions, we may say that to Prof. Alpheus Hyatt it owes its inception, to the Woman's Educational Association of Boston it owes the funds which gave it a start, and to Dr. C. O. Whitman of Clark University, recently appointed to Chicago University, it is indebted for its able direction. There are also many more who have worked as disinterestedly as these for its progress and welfare.

WHALING IN THE NORTH.

IN the old times when navigation was accomplished by means of sailing vessels, before they had been deprived of the good sailors by the ever-increasing number of steamers, a rich profit was made by following the sea and in the fisheries. Chief among the latter was whaling, which, at that time, provided a very profitable occupation for many populated districts of the North, for there were immense numbers of whales in the Arctic Seas. The Norwegians, Danes, English, and Dutch devoted themselves to this business. On account of the icebergs encountered, the bows of the sailing vessels were protected by double planking, and later on by iron armor. The ships carried many boats and a large crew, and after a whale had been sighted from the vessel he was followed up by the small boats. The whale was approached, the man in the bow of the boat threw a harpoon attached to a line, and when this struck the whale the greatest skill and care were required to avoid, on the one hand, a blow from the animal's tail, and on the other hand to provide for the smooth running out of the line, to prevent injury of the boat. The wounded whale would dive rapidly into the depths of the sea, and there was danger that he might carry the boat with him, or, at least, upset it. As soon as the whale returned to the surface for air he was harpooned again, and this was continued until he was so exhausted that it was possible to fasten him alongside of the vessel. Now the cutting up began, blubber and whalebone were taken on board, and as soon as the cargo was large enough the ship started on the homeward voyage. Train oil made from the blubber and whalebone are the chief products obtained from whaling.

After the introduction of steam navigation whaling was carried on by means of steamers that were specially prepared for the work. The improved methods made available by the use of these vessels and new apparatus have rendered the pursuit very attractive. During his recent journey to the North, the Emperor William went on a whaling expedition on one of these new vessels.

Our engraving illustrates the new methods. Fig. 1 shows the slaughtering grounds to which the whale has been towed, as shown in Fig. 4. The harpoon, Fig. 2, is no longer thrown by hand, but is fired off from a gun arranged in the bow of the vessel. The head of the harpoon is provided, in addition to the barbs, with an explosive charge, thus increasing the injury caused by the harpoon, so that the whale will be much more quickly exhausted. After a whale has been taken to the slaughtering grounds the first thing to be done is to remove the valuable whalebones, of which every whale has between three hundred and four hundred. Fig. 6 enables us to realize how small a man looks when in the jaws of a whale. The other figures show the different manipulations—Fig. 8, the bringing in of the blubber, and Fig. 7 the train oil refinery on land—and the remains of the whale are also shown. These are used for the manufacture of guano.

The most exciting moment of a whale hunt is, of course, that in which the vessel comes within shooting distance of a whale or a school of whales. Slowly the bow of the ship is brought nearer to the unsuspecting creature, the harpoon gun is prepared for firing, a man stands ready, and as soon as aim has been taken the gun is fired. When the harpoon has struck the charge in its end explodes, and there is a shower of pieces of fat and flesh, and the sea is covered with red blood. If the men are fortunate the matter is settled by this one shot, and the whale is in the power of the vessel that is following him rapidly and surely.

The number of whales in the Arctic Seas has greatly decreased, in consequence of the great destruction of the animals, and it has been necessary to seek new hunting grounds in the Antarctic Seas and the Indian Ocean. The interest in whaling has decreased as substitutes for whale oil, which was formerly so highly prized, have been found that can be used for lubricating and for other industrial purposes. It will easily be understood that the profit from a single whale is very large when it is known that one which is about 59 feet long weighs 140,000 lb. and gives 60,000 lb. of blubber—from which 48,000 lb. of train oil can be made—and 3,000 lb. of whalebone.—*Illustrirte Zeitung.*

THE kola nut is rapidly increasing in favor as an indispensable adjunct to a traveler's kit. The French Alpine Club has just adopted it as a stimulant and nutrient in their mountain-climbing expeditions. The nut has, it is stated, been found to act most usefully in strengthening a person's "breathing powers" and keeping off muscular fatigue. The German military authorities have, it is said, determined to employ it in the German army. The acting principle of the nut is caffeine.

1. A whale at the slaughtering grounds. 2. The harpoon. 3. Taking out the whalebone. 4. Return of the whaler with the booty. 5. On board the whaler; the whale within shooting distance. 6. In the jaws of the whale. 7. Train oil refinery on the grounds. 8. Cutting up and hoisting the blubber. 9. Remains of the whale to be used for guano.

WHALING ON THE NORWEGIAN COASTS.

[FROM ENGINEERING.]

UNDERPINNING BY MEANS OF GROUTING AND STOCK RAMMING.

By WALTER ROBERT KNIPPLE, M. Inst. C.E.

THE founding of structures is a very important subject for the engineer and frequently presents some most difficult problems, the solution of which taxes to the utmost his experience and skill.

To deal with this subject fully a treatise would be necessary, but I think that an important division of it to which I have devoted special attention, and gained much experience during the past thirty-three years, might be dealt with in one or two articles published in this journal. The division to which I refer is that of securing or making good the foundations of works which, during construction or after completion (perhaps many years after), show signs of settlement or yielding. The settlement may arise from various causes, depending partly upon the nature of the material upon which the work is founded and partly upon the system of construction which has been adopted. For instance, a work such as a quay wall, house, bridge, etc., may be founded on more or less yielding strata, and so long as there is no disturbance of the ground in the vicinity of such structure, and especially no withdrawal of water (or drainage, should the strata be of a peaty or sandy nature), the structure will remain undisturbed; but should any such disturbance take place, then settlement will follow, as has been too often exemplified in the case of deep excavation for works in the vicinity of buildings. Again, it is sometimes found in the case of dock walls that these, owing to an alteration in the condition of the backing or earth filling, due to access of water; or to a reduction of head of water against their face from an exceptionally low tide or other special cause; or owing to dredging in front, by which the resistance to sliding is reduced, move forward more or less, and in several instances such movements forward have been on a large scale and have required the expenditure of considerable sums of money to rectify. Perhaps the class of works wherein failures of foundations have occurred, if not most frequently, certainly most extensively and disastrously, have been those constructed to withstand the action of the sea, such as breakwaters and piers and sea walls for reclamation or protective purposes. Here failure in the great majority of cases is due to the character of structure erected, which consists generally of what might be termed a disjointed or innumerably open-jointed structure resting upon a loose and yielding base, and thus affording the sea ample opportunity to attack it in detail and destroy it piecemeal, which has usually been the case. The class of work which might naturally be expected to be constructed as a breakwater would be of the very opposite character, viz., monolithic throughout, and founded in such a manner as to effectively guard against the destructive action of the sea in storms. Engineers within very recent times are becoming alive to the fact that monolithic work is necessary for breakwaters, and in a number of cases it has been partially adopted, but only as a heavy capping to weigh down or hold in position by friction the concrete blocks underneath, while at a still lower level in the structure the base of loose material is retained. What is perhaps more striking in connection with the system of construction adopted for breakwaters is the contrast it presents to lighthouse construction, where the greatest care has always been exercised to make the work from foundation to cope a perfect monolith, or as nearly so as possible. To effect this object great expense has been frequently incurred in laying the foundations and bringing the work up to high water level, and most elaborate systems of doweling, tabling, and indenting resorted to to insure success. The results have justified the means, for the works have answered their intended purpose, and failures have rarely occurred.

So impressed have I always been with the advantages of monolithic work (that is work without fissure, crevice, or open joint) and the necessity of paying especial attention to foundations in constructing new works, and of repairing or re-establishing the stability of works which from some cause have shown signs of yielding, that I have devoted much attention to such matters, and think that some example illustrative of methods to be pursued to effect these ends (in certain cases) might prove of interest and value to my professional brethren.

In the issues of *Engineering* of October 10, October 31, November 21, and December 28, 1890, there appeared a couple of lectures on "Subaqueous Foundations," which I delivered to the Royal Engineers at Chatham on March 6 and 14, 1889. These lectures, which were fully illustrated by engravings, dealt with new works. In this and the following article I shall treat of the rendering secure of existing works which have become or may become insecure.

Figs. 1, 2, 3, 4, and 5 show respectively sections of a quay wall, warehouse wall, pier of a bridge, a dock entrance, and an embankment of a reservoir. Many examples might be given of failures of each of these classes of works, during construction or after completion. I refer to what may be termed radical failures, that is, failures either from foundation to top, or commencing at the foundation and gradually extending upward. Failures which are confined to the upper portion of any work are independent of the condition of the foundations and do not fall within the scope of these articles.

Failure of foundations of works of the class of those shown by Figs. 1 to 4 are, of course, due to the fact that the load placed on the strata is too heavy to be safely carried. It matters not whether the work fails during construction or many years afterward, the only difference in the latter case being that the supporting power of the strata has become diminished from some cause or other, and generally speaking from excess or from withdrawal of water.

The important point for an engineer to consider is, what is best to be done under such circumstances to prevent a work which is showing signs of giving way from becoming a total ruin. Usually failures of the class illustrated are somewhat gradual, and if precautionary measures are taken in time, the work can be saved by the expenditure of a comparatively small sum of money.

The simplest and most economical manner of procedure is to resort to grouting and stock ramming, whereby the foundations may be increased in width and depth, and the strata rendered firmer. Should the wall be founded on sand or gravel, all that would be necessary would be to put down a series of boreholes of say 3 in. to 6 in. diameter, at intervals along the line of the wall, and several in the width of the wall, as shown by the sketches. These bores go to the bottom of the wall and several inches into the strata underneath, if such be of sand or gravel. Pipes would be placed in the boreholes and thick neat Portland cement grout then passed through the pipes or forced down if necessary, and would thus find its way into the various crevices which might be in the bottom portion of the wall, which it would fill up, rendering the wall solid; it would likewise cement the wall to the stratum of sand or gravel on which it was founded, and this stratum would also for several inches in thickness be cemented together, thus adding a new foundation course below the wall, the breadth of which will be determined by the positions and numbers of the boreholes and grouting pipes used. After a short interval the boreholes could be carried a little lower, and a second solidified stratum added below the first. A third, fourth, or indefinite number of added layers, or foundation courses, could thus be made to the wall, and if the outer boreholes were put down at convenient angles sloping outwardly, each successive layer would be wider than the previous one, and the weight of the wall thus distributed over a greater bearing area.

This means of grouting and solidifying the lower portions of structures is also equally applicable for stopping leaks or runs of water through or under walls or dock entrances. It is necessary, however, in using it for that purpose that the run of water should be temporarily stopped during the operation of grouting, and for a sufficiently long time afterward to enable the grout to become thoroughly set. To attempt grouting while the leak or run of water continued would be useless, as the cement would be carried off by water and thus never have the opportunity of solidifying. If, however, the run of water should be very weak, probably by adding some Medina or quick-setting cement to the Portland cement, or by using partly set neat Portland cement, the leak could be stopped, although in all likelihood some cement would be lost before this was accomplished.

In a number of cases it is quite practicable to temporarily stop the leak or run of water to enable grouting to be done with Portland cement. For instance, in dealing with leaks in graving dock floors and walls, the walls of wet docks, or of dock entrance works, all that is required is to keep the dock gates open, so that the water inside the dock may be at the same level as that outside, when, of course, there would be no run of water through or under the walls or entrance works. Grouting could then be proceeded with, and, after the cement grout is set, the dock gates could be closed, and when the work is subject to its usual head of water it will be found that the leaks are stopped, that is, if the grouting has been properly done. I have stopped many leaks in that way during the past thirty-three years, and since I gave an account of my experiments and practice with Portland cement for such purposes at the Institution of Civil Engineers in 1865–1866 (see minutes of that session, vol. xxv., page 125), many other engineers have adopted it with the most successful results, although in some other cases there have been engineers who, owing to improper preparation of the grout or to inferior quality of the cement, or to having mixed sand with the cement, have obtained results which proved to be failures instead of successes. I shall refer subsequently to the quality of cement and the preparation of grout when describing the work of underpinning the Hermitage Breakwater at Jersey.

If the stratum on which the wall which is giving way is founded should be of clay or a clayey nature, then, instead of forcing cement grout under the foundations, stock ramming should be resorted to, using as materials for the purpose either clay worked up with hydraulic lime, sand mixed with iron filings and sal ammoniac, partly set neat Portland cement or fine Portland, and Medina cement concrete. Such materials should be made up into convenient sized balls or rolls, put into the tubes and rammed down hard with a heavy ram or monkey worked say by hand or steam ringing or pile-driving engine, so as to force them into the soft

IMPROVED METHOD OF UNDERPINNING FOUNDATIONS.

Fig. 1.

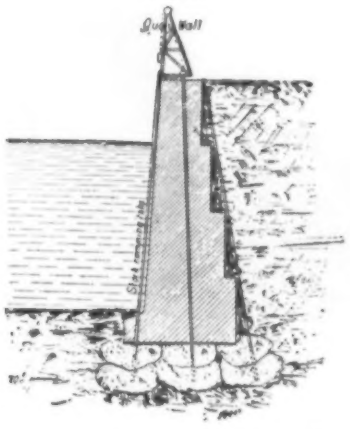


Fig. 2.

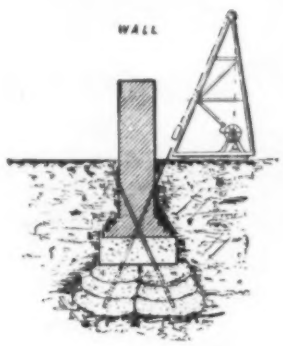


Fig. 3.

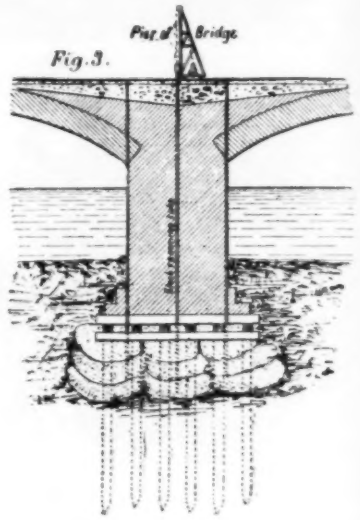


Fig. 4
Dock Entrance

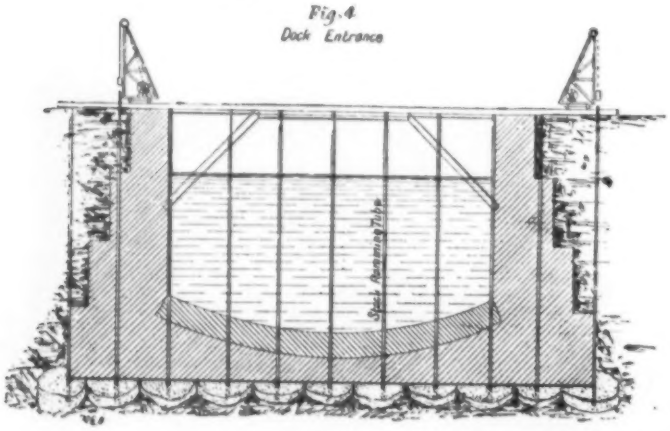
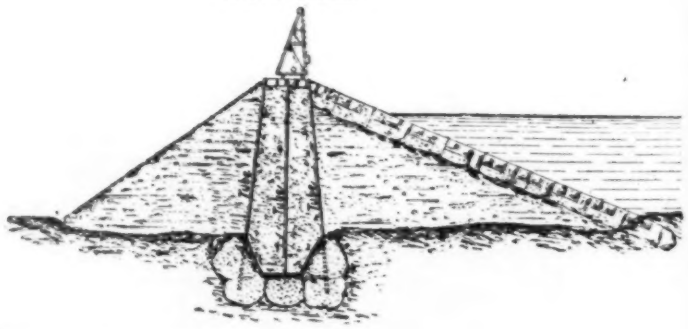


Fig. 5.
Reservoir Embankment



stratum, and thus form under the wall a stratum of harder material extending the full width of the base of the wall, and such additional width beyond the base as may be deemed suitable. When one layer has been completed the boreholes can be carried lower down and another layer added, and so on as shown by Figs. 1, 2, 3, 4, and 5.

This system of stock ramming is especially applicable for stopping leaks, or runs of water in, through, or under reservoir embankments (see Fig. 5), without requiring to empty the reservoir or reduce the head of water in it. I have used it for similar purposes with the most successful results. All that is required is to ascertain the position of the leak, as nearly as possible, put down some boreholes in the vicinity of the site, and ram the clay or other material down very hard. It is not necessary that the boreholes should be exactly on the line of leakage, or water run, as the stock ramming, although it be done at some distance from the run, will force out the strata if sufficiently near to the leak and entirely close it up. It is astonishing the power which can be exerted by stock ramming. In one case I lifted a portion of a dock side by this means, although my object was not the raising of the dock side, but rendering secure the foundations. However, stock ramming could be utilized for the purpose of raising walls, piers of bridges, factory chimneys, etc., or for bringing such structures back to plumb lines should they, as is sometimes the case with factory chimneys, get out of plumb.

I might give a number of instances (see Fig. 4) of dock entrances where stock ramming could be used with advantage, but perhaps if I refer to the case of the Sutton Dock, near Wisbech, that will afford a sufficient example. At this dock the entrance works gave way shortly after the dock gates were closed. The strata upon which the works are founded is of a fine sandy or silty nature and seems to me exceedingly well adapted for treatment by stock ramming. From what I know has been and can be done by stock ramming, I have no hesitation in recommending that system to be adopted in restoring the entrance works, and so enabling the docks to be utilized and some return obtained for the large amount of money which has been expended in connection with these works.

The works to which I have so far made reference have been situated either on shore or, if in connection with harbors, have been in sheltered positions, such as dock walls and entrances.

Works in exposed positions, such as breakwaters, sea piers, and lighthouses, are subjected to such heavy action of the sea that their construction has to be specially adapted to resist these forces. The conditions under which the work of construction has to be done, and the forces which have to be resisted, render it imperative that solidity and massiveness be obtained. Durability otherwise could not be secured. For lighthouses, when of solid construction and exposed to the full force of the sea, a special form of construction has long been in use, and from experience has been found most satisfactory.

The case is otherwise with regard to breakwaters, for subsidences, settlements, and breaches of such works during or after construction are comparatively common, and I think it is by no means creditable to the engineering profession that such should be the case.

It is not that failures of such works are due to scamped work, or to niggardly expenditure, unduly limiting the amount to be spent, and thus forcing the engineer to adopt too weak a design. On the contrary, the cost of the work per yard run is unusually high, and as it is generally done directly by a government department, or harbor board, without the intervention of a contractor, there is no object in scamping the work. The failures which take place are not to be attributed to such causes, but to the design itself, which for recent breakwaters of importance may be described as consisting of a rubble base, or mound, surrounded by a wall constructed of large sized blocks of concrete, with open joints between all blocks, and on the top of the blocks a capping of concrete *in situ*. It is high time that this system of construction was abandoned. It has been attended with failures of greater or less extent in the past, and I have little doubt will be so in future, even although some of the structures of this type have, up to the present time, shown no signs of yielding. It is a question of time, a repetition of big storms, or a storm of exceptional severity, the effects of which, extending to a lower level than usual, disturb the comparatively small and loose materials of the rubble, and being so dislodged, the heavy structure on top becomes undermined and gives way, either piecemeal, as in some cases, or in masses of over 1,000 tons in weight, as at Wick. Were such failures unavoidable it would be useless to find fault, but with a constructive material like Portland cement at the disposal of the engineer, breakwaters ought to be constructed with as little liability to failure as any other class of works, and their durability and small cost for maintenance ought to be on an equal footing. This can only be obtained in exposed positions (and it is to such I refer) by making the work monolithic from foundation to cope. Absolute security would thus be obtained, and not only security, but saving in cost, as the minimum section of breakwater could be adopted where the work consisted of one mass, which cannot be done with an open jointed or disjointed structure, where each block or portion of the work has to depend on its own weight for stability, assisted perhaps by the additional weight of a superimposed mass. But in reality comparatively little aid to any particular block, or series of blocks, can be counted upon with certainty from such mass or capping, as although its weight upon the blocks may be considered to be fairly and uniformly distributed immediately after completion of the work, yet the slightest settlement of the foundation afterward at any part (and this is a common occurrence) immediately relieves the top of the blocks from the weight of the superincumbent mass, and the blocks have only their own weight to depend upon for stability. So that in structures of this class the stability of the blocks themselves can only be relied upon. A help to a certain extent is obtained by means of cramps, and also of grooves and joggles, but this is only a small step in the direction of the monolithic system of construction, which, without doubt, is the proper one to adopt.

(To be continued.)

MANUFACTURE OF PAPER ON THE CONTINENT.

WHEN we refer to collections of journals of but forty or fifty years ago, we are much astonished to see before us sheets whose size rarely exceeds that of our present one cent papers. Moreover, the daily edition scarcely exceeded a few thousand copies. The great idea of the cheap press, it is true, had but just been put in practice by Emile de Girardin, and, although the paper machine invented by Louis Robert in 1799 had long permitted of dispensing with hand-made paper, it was far from having reached the capability of production that it now possesses. There was likewise a great revolution to be made in the selection of the raw material. Rags, which until then had been exclusively employed in the manufacture of paper, had become both too scarce and too dear to allow their use to be continued as the sole supply for a demand that was increasing beyond all foreseen limits. It became necessary to restrict the use of them for the choicest and costliest papers, and for others to find raw materials which, while giving them the proper strength and grain, should permit of lowering their price to the exceptional figures at which we see them to-day. This is what constitutes the industry of rag substitutes, and which utilizes, with proper treatment, alfa, straw, and wood reduced to a pulp. All fibrous substances might be converted into paper, but the product obtained from them is usually too small to allow them to become the object of an industry, and it has become necessary, in practice, to make a choice of the substances just mentioned.

All these materials undergo successive preparations that we shall briefly describe, and then they pass into the paper machine, which is the principal agent of manufacture, and finally into accessory machines, such as calenders, cutting machines, etc.

The rags are first given into the hands of women, who cut them upon a knife placed in front of them upon a bench, and who separate from them such objects as hooks and eyes, buttons, and pieces of wool, silk, and leather, and then class the product of their work or sorting between twenty baskets, which go to the storeroom.

After this the rags are cut into smaller fragments and put in quantities of 2,200 pounds into a cylindrical vessel having a rotary motion and containing lime water. Heating is effected through the introduction of steam under a pressure of from 2 to 4 atmospheres. The lime removes the greasy matters and the steaming prepares the rags for their ultimate conversion into a pulp. At the end of a day the material is ready to pass the stuff engine. The present lime treatment replaces the rotting which was formerly done in vats, lasted from six to twenty days according to the nature of the rags, and was followed by a washing with water and a trituration in mortars by pestles covered with iron and actuated by a cam shaft.

In the stuff engine (which is an oblong trough) there revolves a cylinder armed with blades and situated opposite a stationary piece, which is also provided with blades. The passage of the rags between the two apparatus reduces them to a pulp. The trough is separated in the direction of its long axis by a partition which permits of the circulation of the pulp. Opposite the cylinder there revolves, with a much slower motion, a drum covered with wire gauze, through which the dirty water escapes, while the meshes retain the pulp fibers. In addition, an arrangement at the bottom of the trough arrests all the heavy objects, such as buttons, etc., that have not been attacked by the alkali.

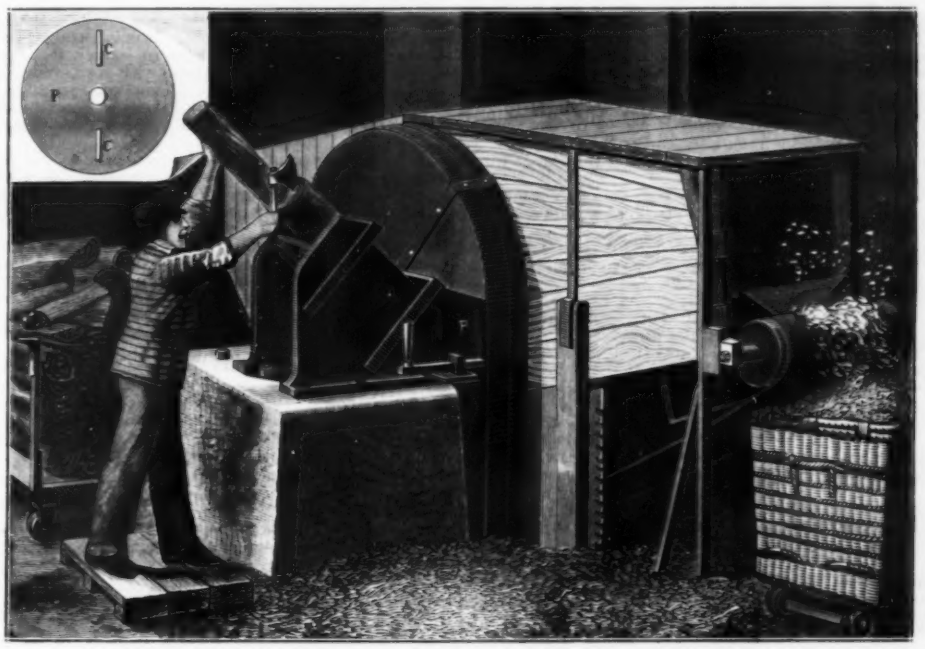


FIG. 1.—MACHINE FOR CUTTING WOOD IN THE MANUFACTURE OF CELLULOSE.

These engines are situated in the second story of the building, so that their product can pass by gravity to the first story into vats of the same form, containing a solution of chloride of lime, and called bleachers. The stirring of the mass is effected through a wheel with paddles. These vats are made of cement, while the others are frequently of metal.

Alfa or esparte, which is especially employed in England, is carefully sorted and submitted to the action of soda instead of lime, at a pressure of four atmospheres. The operations of cutting and bleaching are the same as for rags.

The manufacture of straw pulp is much more general in France than that of alfa. All kinds of straw are used, and, as one gives just as good results as another, they are worked without distinction. After they have been cut by the chaff cutter, and then freed, by winnowing, of their spikes, knots, dust, etc., they are introduced into a lixiviating cylinder (either stationary or rotary) under a steam pressure of from 4 to 6 atmospheres. A six hours' treatment with steam suffices for a charge of 2,200 pounds. At the end of this time, the

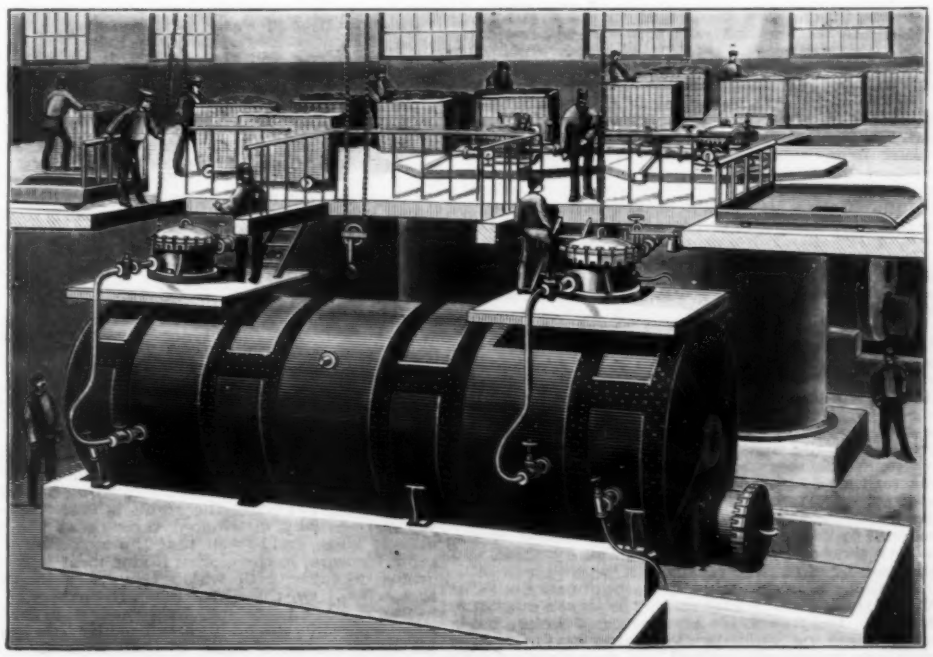


FIG. 2.—APPARATUS FOR TREATING CELLULOSE WITH BISULPHITE OF LIME.

pulp is put into double-bottomed vats, where it drains and from whence the lye is extracted, to be converted again into caustic soda. If the pulp obtained is very good, it is washed with water in the same vats, and is then bleached in large basins under the action of chloride of lime. There is nothing further to do but to drain it in order to render it ready to be worked. The product in bleached pulp is about 40 per cent.

This manufacture can be remunerative only on condition that the soda is recovered from the lye. To this effect, the lye, as well as the first washing water, is evaporated in special furnaces (Porion's) which arrest the bad odors. The salts obtained are dissolved, and made caustic by lime. The latter, in turn, as a residuum of the operation, gives an excellent fertilizer. The revivification permits of recovering 80 per cent. of the soda employed.

The woods that are used in the manufacture of paper are treated in two different ways, one mechanical and the other chemical. In the first, soft woods are especially employed, such as the aspen, poplar, etc., and in the second, the fir, and particularly the silver fir, which furnishes a very pure cellulose.

The mechanical pulp is obtained by abrading, on a horizontal grindstone, billets of wood 12 in. in length arranged in cells and held by clamps against the perimeter of the stone. A continuous current of water carries along the pulp formed, and which is further refined by another mill before it passes to the lixiviators. Norway, which, as well known, is widely covered with forests, furnishes Europe with a very large quantity of mechanical wood pulp.

The chemical pulp, which was formerly made by treating wood with caustic soda, is now almost universally obtained by the action of bisulphites, and particularly of bisulphite of lime. This process, which appears to have been first adapted to industrial practice by Dr. Mitscherlich, has received various improvements in Sweden, Austria, and France. It gives more economical results than soda, because of the much lower price of the bisulphite of lime.

The wood, which is in general that of the silver fir, is washed and decorticated, and then cut by a circular saw into billets three feet in length, and finally split by a machine. In this state, through the aid of an inclined box, it is presented to a mechanical cutter (Fig. 1), composed of a cast steel disk provided with two radial steel blades and revolving with great rapidity. This machine furnishes 35 cubic feet of wood shavings in the space of six minutes, and these shavings are thrown into baskets, whence they are afterward taken and spread upon wide tables provided with a grating through which the dust passes. The remains of knots or bark that would not be well adapted for treatment with alkali are carefully picked out by women. The shavings are then taken to the first story in baskets and put into the lixiviating apparatus. As the latter presents a few peculiarities because of the extremely corrosive action of the bisulphite of lime, we shall first speak of the manufacture of the bisulphite. This is obtained by the reaction of sulphurous acid produced either by the roasting of pyrites or by the burning of sulphur upon a column of limestones. The gas traverses this column from bottom to top, and the reaction is facilitated by a showering with water in the opposite direction, and so regulated as to give a lixivium of a proper density. The bisulphite formed is collected at the base of the column. It is a colorless liquid, of an odor as suffocating as that of sulphurous acid, and attacks all the common metals except lead. So the iron plate lixiviating apparatus have to be provided with a lining of cement, upon which are laid several sheets of lead (Fig. 2). Besides, they are inclosed in masonry of refractory brick, which are themselves covered with lead, and all the openings for the introduction or removal of the material are lined with the same metal.

These apparatus, which are of a very large capacity (1,400 to 1,800 cubic feet), are stationary or rotary. A worm made of an alloy of lead and antimony permits of the introduction of steam into the apparatus in order to raise the bisulphite to a temperature of 130°; but, as the steam might blacken certain parts of the pulp, it is introduced either through a double bottom or through lead worms with which the sides of the apparatus are provided.

The reagent removes the gummy and resinous substances, and these are retained in a residuum of sulphate of lime, while the cellulose remains in a practically pure state. In order to free it from the last traces of acid and resinous substances, it is washed with water, without any trouble being taken to collect the residua, which have no value. But the cellulose, which has preserved the appearance of wood, must be reduced to finer pulp in order that it may be pumped to the purifying apparatus. So, on coming from the lixiviating apparatus it passes into large vats, where it is submitted to the action of an agitator that keeps it constantly in motion. From thence it is forced to the purifiers, which comprise the collectors (long wooden conduits, in which the heavy matters are deposited), and the sifters, which consist of boxes with a movable bottom provided with apertures that let the good pulp pass, and retain all else.

The pulp is finally drained in conical rotary sieves, and can then be directly employed for many papers, such as those upon which journals are printed, colored papers, etc.

However, it has to be bleached by the mixtures designed for the finer papers. To this effect, there is now used a very ingenious process of electro-chemical bleaching, devised by Mr. E. Hermite. It consists in the decomposition of calcium or magnesium by the passage of an electric current. This forms a liquid possessing a most intense decolorizing power. In the presence of the vegetable fiber, the primitive salt is regenerated in measure as the bleaching proceeds, so that at the end of the operation the same bath can be used again. The sole loss of chloride is what the fiber has taken from the bath. The entire expense, then, is reduced to that occasioned by the production of the motive power necessary to actuate the dynamos, and the keeping of them in repair.

Finally, we may consider the waste of paper mills, or that of the industries that employ paper as a substitute for rags. Old papers are always sorted before being used. Those containing printed matter are first treated with soda before being refined, and then bleached with chlorine. They are afterward taken to granite millstones joined in pairs and running vertically over a third and horizontal stone inclosed in a cast iron vat, into which water is run while the waste is thrown in. The same operation is applicable to the Norwegian mechanical pulp, in order to render it finer and more homogeneous.

The various pulps that we have just examined, being obtained either in the same mill or purchased outside, have to be mixed according to the qualities that it is desired to obtain. Delicate fibers, like those of cotton rags, yield a thin pulp and flexible and soft papers. Coarse and strong fibers, like those of hemp and flax, furnish a thick pulp and a transparent and smooth paper. Mechanical wood pulp, the fibers of which are very short, adds opacity and body, but quickly becomes yellow. Cellulose, which forms chemical wood pulp, furnishes an excellent paper, silky and soft to the touch and well adapted for printing. Straw pulp has shorter fibers than those of the preceding, but gives transparency and uniformity. Finally, alfa comes nearest to rags, and constitutes the substitute therefor *par excellence*.

The mixture is made in beating engines, which are established in series of three. It is in these apparatus that the paper is sized in order to render it impermeable to ink. The sizing is done with a resinous soap, prepared by melting resin with carbonate of soda. The addition of a little alum to the vat precipitates a resinous compound of alumina, which agglutinates the fibers.

A weighting composed of kaolin, plaster, sulphate of baryta, etc., is used for common papers, of which it corrects the transparency and to which it gives whiteness. From 5 to 20 per cent. of fecula is generally added to it, in order to fix it better to the fibers. Finally, the coloring, when pulps formed of colored rags are not used, which is most generally the case, is done by pouring the colors into the vat through a very fine sieve or through flannel. The invention of aniline colors, which are all soluble in water, has made this part of the manufacture easy; but these colors are unfortunately sensitive to the action of light.

The beating engines are in immediate communication with the large vats that form the head of the paper machine. We have now arrived at the end of the preparations, and in a succeeding article we shall touch upon the manufacture properly so called, either by hand or machine.—*La Nature.*

RUSCHER'S PROCESS OF SUGAR CRYSTALLIZATION.*

THIS invention concerns the process for boiling impure sugar solutions to grain in sugar houses and refineries, and to do this in such a manner as in a single operation to avoid all low produce, producing on the one hand crystallized sugar in the form of raw sugar and exhausted molasses having a purity coefficient of about 63.

The reducing or entirely suppressing the work of low products has been considerably investigated. Dr. Wulff endeavored by crystallization in movement to accelerate the crystallization of sugar present in the solution, and he hoped in this way to reduce the production of low products. Mr. Steffen added molasses to the masse cuite, with the view of entirely suppressing low products under his method.

The object of the present invention is to be reached by a special method of boiling sugar solutions to grain and by a special treatment of the masse cuite thus obtained, which treatment is new and very effective, industrially, and is of such a kind that by the separation of the grain formed in the mother liquor there is obtained without other addition and without means resembling those of crystallization in movement, all of the crystallizable sugar, and this at one time, and the molasses has a purity coefficient so low that further boiling would not produce crystals in it.

The new invention is based on the knowledge of the fact that to realize the end indicated above, it is necessary, in producing the masse cuite, to establish all the conditions which will permit the molasses to form, and which offers all of the molecules of crystallizable sugar the opportunity of incorporating themselves with the grains of sugar already there.

The exhausted molasses, we may say, would be that containing no more than 50 per cent. of crystallizable sugar, 30 per cent. non-sugar, and 20 per cent. of water. With about three parts of non-sugar, there would then be in the molasses about two parts of water. If the proportion of water is larger than is required for the formation of the molasses, there will be more sugar in solution, and the mother liquor, from which we are endeavoring to eliminate it, would still contain crystallizable sugar that would have to be secured as a low product in subsequent work. When, however, the proportion of water is too low, the masse cuite becomes sticky and gummy, and, in order to become manageable, frequently requires an addition of sirup, which also occasions the reintroduction of crystallizable sugar into the mother liquor.

The preparation of the masse cuite that is to be submitted to chemical control during manufacture should then be so directed as to obtain the proportion of 3 to 2 between the non-sugar and the water. The masse obtained under these conditions is discharged from the vacuum pan and placed in shallow reservoirs. These reservoirs, or boxes, should be so arranged that the masse cuite therein should not exceed a thickness of from 4 to 6 inches, as otherwise the formation of the molasses would not be sufficiently promoted.

The contents of each box ought to be kept within the limits of 25 to 35 pounds of masse cuite, if it be desired to avoid subsequent melting. By this use of flat boxes the deposition of the mass of the grains of the masse cuite on the bottom of the box is promoted, and a layer of thick sirup is formed above the bed of crystals, in which there are almost no floating crystals.

With these flat boxes the result is that the mother liquor is equally distributed throughout the entire mass of grain, and so well that the molecules of crystallizable sugar in the mother liquor meet everywhere grains of sugar with which they may incorporate themselves. On the other hand, the grains of sugar in the masse cuite are sufficiently near and the bed of sirup separating the grains is sufficiently thin to enable all the crystallizable sugar to unite with the crystals. Then, as in the usual processes, they can be subsequently secured. This is a condition indispensable to the success, for the sirup, everywhere impregnated with crystals, cannot abandon its crystallizable sugar in such a way as to form gum, the crystallizable sugar feeding or enlarging the grains already formed.

The boxes are permitted to cool slowly, and for this purpose they are left about forty-eight hours in a heat-regulated room. During this time all the crystallizable sugar separates itself from the mother liquor, and this latter forms then an exhausted molasses having a purity coefficient of about 63. The separation of this molasses from the crystals then follows after the crystallization, and in centrifugals in which the masse is dumped from the box without breaking and without dilution, at least when small boxes are used. If, on the other hand, large, flat boxes are used, it is well to dilute the masse cuite with molasses before centrifugaling. To promote the separation, high speed centrifugals should be used.

The processes can be applied with equal advantage in sugar houses and in sugar refineries. In the latter, and especially where they desire to produce mould sugar and granulated, the raw sugar is washed ordinarily with steam or water or sirup before melting, in order to eliminate rapidly and as completely as possible the non-sugar enveloping the surface of the grains. The crystallizable sugar which is thus dissolved is subsequently recovered in the low products as third, fourth and fifth sugars.

By this new process there is dissolved with the non-sugar and the raw sugar, by a wash with steam, enough grain sugar to obtain a sirup or masse cuite having a purity of at least 85, which is then cooked into grain.

In treating the new masse cuite afterward, according to this plan, the boiling of low products in the refineries is suppressed, and in the cycle of operation there is obtained an intermediate product equal in quality to the raw sugar taken into the work, a product which may thus be mixed with raw sugar and constitute close work. All the low products are suppressed.

The process is specially advantageous in refineries which produce only sugar crystals and mould sugars.

* Translated for the Louisiana *Planter* from the *Neue Zeitschrift.*

WHAT IS THE CAUSE OF PAINT PEELING ON OUTSIDE WORK?*

THIS subject was discussed at a recent meeting of the Society of Master Painters and Decorators of Massachusetts, Worcester, Mass.

The president introduced B. W. Wentworth, of Waltham, to open a discussion. Mr. Wentworth said: I have had some experience in painting, but whether I know much about it, after all, some of you will have to decide. The matter of paint peeling on the outside is largely due, I think, to zinc mixture, as it is in all our houses. It affects the wood with water, and paint is bound to peel in a case like that much more readily when there is zinc in it. I don't mean to say that lead won't peel. I think it is much more liable to peel where there are more than two coats. It is apt to rise and blister and dry down again, while zinc dries very hard. Wherever there is a mixture of zinc the paint curls up, while lead will lie right flat. I think a mixture of lead and zinc has a good deal to do with it. I think that on the north side of a house, where there is so much moisture, it cracks and draws up. I have noticed that where the blinds lie back against a building, showing that the moisture that lay in back of that blind caused it to shrink and draw up. Two coats of paint is not waterproof. I think, as I said before, that the prime cause of paint peeling is the use of zinc. Zinc came round about 1850. I never knew any trouble about paint peeling till zinc was introduced. Where zinc is used you will invariably find that the paint will come up in blisters. Break these blisters and you will find them full of water. I have found that while white lead is not a perfect paint, it is the nearest that can be found.

Mr. Hand, of Brookline.—I doubt if any painter in the country is able to answer this question. It seems to be a question that no one is prepared to answer. There are many reasons that could be given in the first place for paint peeling. I don't know that zinc has much to do with it. I can't quite agree with our friend from Waltham on that point, for barytes will cause paint to peel.

At the sea coast a cat boat will always get white with salt water, and when paint gets white with salt water it is sure to peel off. Carpenters have the idea that unless you prime work the work is entirely spoiled. I think the carpenter should let the work stand a week or two weeks and then paint it. It is the proper thing to do to let the work stand a week or two before it is primed. I think that the matter of salt water has a good deal to do with paint peeling. Water getting behind the paint and the sun will draw paint. There are several reasons, but all those things are theories. Some may think that salt water in bark can be washed out. I have no doubt there is a fortune in store for any one who can discover a remedy. Any painter who can give a definite reason why paint peels is entitled to be considered a most intelligent man in this community.

Secretary Wall.—I am thoroughly convinced that in ninety per cent. of the cases where peeling is due to water getting behind the paint, barytes will be found to be the cause, and whether the boards be spruce or pine, you'll find that the moisture is extracted in the direction of the greatest heat. It is sure to get out, and it makes little blisters, which we can prick and the water will flow. I don't say that is the whole of the cause, but I am convinced that water is ninety per cent. of the cause. Behind the blinds you'll frequently find that paint is peeling. Why should the blind peel on the outside or at the back? I have seen blinds blister from end to end, and there seemed to be no reason why water should cause that. Water is a very peculiar thing in connection with paint. I think a good deal of the peeling is due to the fact that priming is done as soon as the work is put up. I am so firmly convinced that, when I have another house to prime, I shall let it stand a week or a month. I find that in many places with a partition of two and one-half inches you can stand the painting and carry it right along. I hold that the peeling is due to moisture, for where

* From *Painting and Decorating.*

the paint dries hard it stays there. Therefore, gentlemen, my opinion is that ninety per cent. of the peeling of paint is due to water.

Mr. Ackers.—During all my experience of forty-five years I have been in business I know of but one case of paint to peel. Japan, in nine times out of ten, is at the bottom of it. Take some of our very best of lead and paint with it the best of wood; give it three coats of paint with that japan which we have to-day. Stand it out in the sun, and I'll wager $100 against a cent that paint will peel inside of two months. Let the painter make his own japan, and make it from oil, and you'll find that ninety-nine times out of one hundred the paint would not peel.

Mr. Wentworth.—Yes. There was a very able article in the last magazine on that very point. We are not discussing the blistering of paint, but the peeling of paint. I would like to ask Brother Hand if he would be willing to paint a house with two coats of zinc. I would like to have some expression of opinion on that subject.

Mr. Lincoln.—I have had twenty-seven years' experience in the business, and my opinion is that the clapboards are the cause. Twenty-five years ago there was no great hurry about painting a house. My theory has always been that the cause of peeling is the clapboards not being perfectly dry when they are put up. The lather goes into the building when all his laths are soaking wet, and the water and all this dampness from the inside must dry out somewhere. It can't dry in the house, and so it must dry on the outside. When I went to learn my trade we never thought of painting a house without first shellacking it. To-day where is there a painter who uses shellac on any house? Give your clapboards plenty of time to dry, shellac your knots, and you will have no peeling.

Mr. Wall.—I think that where houses are painted as quickly as they are now there is always some liability of peeling. There is no oil in the market to-day that does not contain water. As Brother Ackers said, you take good oil and you will get little water. There is nothing draws the sap out of wood like water.

Mr. Hand.—There might be something in that matter of japan, but there is certainly more in Mr. Wall's theory about the water in the oil. Those houses, I notice, are peeling which have been painted with oil in which there was a large percentage of water. They are blistered and peeled, and that is something that cannot be accounted for. Break one of those blisters, and you get down to the priming in the wood.

Mr. Short.—It was a very rare thing forty years ago to see paint peel.

Mr. Ackers.—About six years ago I went to look at the first house I painted when I was an apprentice, and it had never been painted since for forty years. It was primed with clear oil, there was no japan used in it, and that house stood the test of years, and looked as well as most of the newly painted houses that I saw.

Mr. Wall.—It seems to me that a good deal of the peeling is due to the fact that spruce clapboards are used now instead of pine. I saw a job last fall that was primed on the outside before it was lathed. Heat was put in to dry it. About a week or so after, the plaster was in and began to get dried. I noticed a sort of white appearance beginning to show on the outside. I could take my hand and rub it off like whitewash. What would have been the result on that clapboard had it been lathed first and primed afterward? About the water question and the water in the oil, I don't think it amounts to much. If you mix water and oil in the paint pot and stir them up, the water will evaporate.

Mr. Hanker.—I have a house at Pittsburg which is peeling, and I can't tell the cause of it. It was primed with ocher, then given two coats of mixed paint, but I find the house peeling. It peels to the ocher. Then I went round the whole house with two coats of paint. The last coat was made nearly all oil, but the paint has peeled off clear to the wood. Since then we have found out that the cause was due to water about the building.

AN IMPROVED METHOD OF DETERMINING SMALL PERCENTAGES OF SILVER AND GOLD IN BASE METALS, MATTES, ETC.*

By CALEB WHITEHEAD, Assayer to the Mint Bureau, Washington, D. C.

ANY one having frequent occasion to report the values of silver and gold in such material as crude copper, copper mattes, or ores, metallic iron, zinc, etc., will appreciate the advantages of a method which affords accurate results with little expenditure of time. The large production of pure copper by electrolytic methods from silver and gold-bearing copper ores renders some such method very desirable in view of the various transfers of—(1) ores to the smelters; (2) mattes to the refiners; and last, the crude copper to the electrolytic refinery; each of which transfers carries a commercial charge of the bullion contents.

While the proposed method is available for a great variety of base products, it will perhaps be best illustrated by its use in determining the silver and gold contents in crude copper, or the mattes resulting from bullion-bearing copper ores. The adaptability of the method to other base metals will readily suggest itself to the experienced assayer.

Given a crude copper or matte carrying from 30 ounces of silver and 0·10 of an ounce of gold upward, the usual method would be scorification. It is usual to take for assay from 0·05 to 0·1 assay ton to each scorifier, with which are used from 40 to 50 grms. of test lead, one-half of which is mixed with the ore in the scorifier and the remainder used as a cover. The scorifier is now introduced into a hot muffle and the door closed until the lead is melted, when it is opened, and about 1 grm. of borax glass placed on the lead. Oxidation begins at once, and the lead and base metals are rapidly scorified off until the slag covers the metal, when the assay is poured into a mould. If the lead button still retains much copper, or is hard or brittle, it is again scorified, with the addition of more test lead if necessary. When the lead button is soft and of proper size, it is cupelled and the button weighed and parted. Several scorifications are sometimes necessary before the button is ready for the cupel.

The two objections to this method are, first, the loss of silver during scorification and cupellation, the latter due mainly to the copper remaining in the lead, which it is practically impossible to remove in the scorifier, and which takes silver into the cupel. These losses I found to amount to from 2·33 to 2·78 per cent. of the silver present in the copper. My experiments were made with pure copper and pure silver, the silver being added in the proportion of 100 ounces per ton of alloy.

The second objection is the small amount of bullion which can be operated upon, which necessitates the use of many scorifiers where small amounts of gold are to be estimated, which is usually the case.

To avoid the doubtful results of scorification processes the following method has been adopted at the copper works of a firm having large interests at stake:

One assay ton of copper is dissolved in nitric acid, diluted, and allowed 24 hours to settle. The solution is now filtered from the slight sediment containing the gold. A few drops of hydrochloric acid are added to the filtrate and the solution again allowed 24 hours for silver chloride to deposit, when it is filtered, washed, and the two filters dried, combined, scorified with test lead, and cupelled. The chief objections to this are (1) the time required; (2) the small amount of precipitate obtained and the danger of loss in scorifying silver chloride; (3) the greater solubility of silver chloride as compared with the bromide.

While the method used at these works is an advance over previous practice, yet the time employed and the uncertainties indicated leave much to be desired. The protracted time allowed for settling is necessitated by the exceedingly fine condition of the gold resulting from the solution of a metal carrying possibly from 0·10 to 5 ounces of gold per ton of metal. It would pass through a filter unless allowed to aggregate by standing.

The larger quantities (say 100 ounces) of silver per ton will give but a slowly subsiding cloud (impossible to filter) when newly precipitated as chloride. The scorification of these combined precipitates, one of them being silver chloride, cannot give results quite satisfactorily, despite the time involved, some 48 hours at least.

The method which I will now briefly describe was devised to meet just such cases, and is suitable for the bullion valuation of zinc, iron, nickel, etc., as well as the sulphides and arsenides of iron and copper. To illustrate the proposed method, which has been found effective and useful, the treatment is detailed for a crude metallic copper carrying both silver and gold. It will be understood that sodium bromide is chosen as a precipitant because of the greater insolubility of silver bromide over the chloride, and also that the soluble lead salt is added in order that the heavy precipitate of lead bromide may envelop and promptly carry down the silver bromide cloud, which otherwise would require long waiting for its subsidence, as well as to furnish the lead necessary for cupellation.

Weigh out from one to four a. t., depending upon its richness, place it in a beaker of 500 c. c. capacity, and add gradually enough nitric acid to dissolve it completely, heat until red fumes cease to come off, dilute with water, and add 50 grms. of lead acetate, stir, and when dissolved add 1 c. c. dilute sulphuric acid, and allow the lead sulphate to settle. Filter into a 1,000 c. c. flask, and fill to the mark with distilled water.

The filter contains the gold which has been collected and carried down by the sulphate of lead. The filter paper and precipitate are dried, the paper burned and the ash and lead sulphate scorified with test lead. The button is cupelled and the gold, with any trace of silver it may contain, is weighed. Add silver and part the gold in the usual way. Note the amount, if any, of silver found, and include the proper proportion of the amount with that found in the solutions as about to be described.

In order that there may be a control assay, the solution is divided into two equal parts, to each of which a saturated solution of sodium bromide is added with constant stirring as long as a precipitate is produced. The precipitates settle quickly and filter and wash well. Cold water only should be used, and the washing be continued until the washings are free from copper. Any bromide of lead dissolved during the washing may be neglected, as I have never found it to contain more than a trace of silver, even when assaying ores carrying many thousand ounces.

The precipitate when dry can be brushed from the paper without difficulty, and thus the trouble of burning the filter is avoided. The bromides are now mixed with three times their weight of carbonate of soda and a small amount of flour or other reducing agent placed in a small crucible covered with borax glass and melted down in the muffle. The button should weigh about 2 grms. and be free from copper and other injurious impurities. This button is cupelled at a low temperature, so that the cupel "feathers" nicely. The time required is from three to five minutes. Duplicate assays usually agree within two-tenths of an ounce per ton.

The following examples are from copper bullion:

	Silver. Ounces.	Ounces.	Gold. Ounces.
No. 1.....	61·30	61·20	0·10
No. 2.....	63·45	63·30	0·17

Had the gold button contained silver, one-half of its silver contents would have been added to the silver recovered from the solutions, since the gold is estimated on the whole weight, while two determinations of silver are made on the same weight.

The following is an example from a silver-bearing cast iron from the U. S. Mint at Philadelphia. It was dissolved in nitric acid, diluted, and precipitated with lead and sodium bromide. After washing, the bromides were dried and brushed from the filter. No. 1 was mixed with 10 grms. of litharge, a little flour, the usual amount of soda, and covered with borax. Melted down and cupelled the button gave 30·80 ounces per ton. No. 2 was mixed with test lead and borax, and scorified. It gave 29·90 ounces per ton, 0·90 of an ounce less than No. 1. However, this would be considered a very close agreement by the old method.

The following is an ore from Colorado, very base and with a gangue of sulphate of barium. It proved very unsatisfactory to assay by scorification, duplicates not agreeing at all. The ore was treated with nitric acid and filtered, the residue being assayed separately.

The following are my results:

	No. 1. Ounces.	No. 2. Ounces.
Residues.....	32·50	35·95
Solutions.....	454·90	453·30
As a total.....	487·40	489·25
Difference of.....	1·80	—

Gold was not separated in the residues. The highest assay gotten by scorification was about 467 ounces, which shows 20 ounces in favor of the new method, with a reasonably close agreement in different assays.

* Read at the Chemical Section of the Franklin Institute, May 17, 1892.

FRICTIONAL AND GALVANIC ELECTRICITY.

SPEAKING generally, it may be said that when any two bodies are rubbed together electricity is produced, although it frequently happens that the amount is so small as to render its detection very difficult. If, however, delicate apparatus is employed, very feeble charges can be indicated. In fact, if a piece of zinc and a piece of copper are simply placed in contact, the feeble charge of electricity then developed can easily be rendered evident. If the same pieces of metal are placed in saline or acidulated water, a similar result follows, although in this case the water itself becomes an important factor in determining the resultant electrification. The end of the zinc outside the liquid will be found to possess properties similar to those of sealing wax after it has been rubbed with fur. It is, therefore, said to be negatively electrified. The copper, on the other hand, will have an electrical state similar to that of the fur itself, or of glass which has been rubbed with silk, and it is therefore said to be positively electrified.

It follows that whether the electricity is the result of so-called friction or whether it is a consequence of the simple contact of two dissimilar bodies, it is with precisely the same kind of force that we have to deal, and the old distinction between "frictional" and "galvanic" electricity, which used to be urged with considerable persistence, is virtually a myth. The quantity of electricity may vary, and we may view it in its two phases, positive and negative, but neither of these considerations can affect the character of the force.

It may be accepted as a general fact that when the same kind of force is bestowed upon two points or bodies, but to a different extent in the one case as compared with the other, there is a universal tendency to equalize the distribution of the force, that is to say, to produce equilibrium, and this equilbrium will be established when the conditions become such as to render it possible. Reverting again to the zinc and copper plates partly immersed in water, the exposed ends will be electrified to different degrees. There will be a tendency to produce equilibrium, or, as it is more generally called, neutralization. This will be accomplished if the necessary facilities are afforded, and until this is done the intervening space will be subjected to what may be called electrical stress. It is found by experiment that a piece of metal affords the readiest means of relieving the strain due to this stress, thus facilitating neutralization, for on joining the two plates together, say by a piece of copper wire, a momentary rush of electricity from the one end to the other will take place. This phenomenon is that which is generally known as discharge, and it affects the whole combination, including the liquid and the metal surfaces in contact with it.

This brief spasmodic flow or rush of electricity, whose function it is to restore the electrical equilibrium, causes, however, a series of chemical changes to take place in the liquid itself, among other things a portion of the zinc being dissolved and converted into what is called a salt of that metal. These chemical reactions cause in their turn a fresh electrical difference between the plates, which is followed immediately by another equilibrating flow, and that by another difference, and so on.

These changes follow one another in exceedingly rapid succession, so rapid, in fact, that it is a matter of absolute impossibility to distinguish them separately, and we have consequently what appears to us as what is known as a continuous "current" of electricity.—*Electrical Age.*

ELECTRICAL RESISTANCE OF THE HUMAN BODY.

By M. VON FREY.

THE author has applied to the human body Kohlrausch's method of determining the resistance of electrolytes by means of alternating currents and the telephone. Certain modifications were at once found to be necessary. It was necessary to dispense with the meter measuring wire, since its resistance is so small compared with that of the human body that, in order to hear any sound at all, it is necessary to use induction currents so strong as to be painful to the subject of experiment. The author replaced the measuring wire by a circular groove not completely closed, filled with solution of zinc sulphate, in which the part connecting it with the telephone could be moved round like the hand of a clock. It was further found that platinum electrodes of 10 to 20 square centim. surface, which Kohlrausch found quite sufficient for measuring the resistance of liquids, are by no means adequate with the human body to produce a cessation of the tone in the telephone in any position whatever. It was only when the surface of contact between the metal and the moist hand was increased to several hundred square centimeters that the tone ceased, or at any rate there was a very pronounced meniscus. The surface necessary varies with the region of the body. In order uniformly to moisten large surfaces of the body, they were immersed in troughs through which the current was passed by cleanly polished zinc plates. In such conditions the resistance of the body was found to be very small (from hand to hand 3-400 ohms), and, as was to be expected, independent of the induction currents.

In order to utilize the method for electro-diagnostics, in which a very small electrode is always used, the author replaces the metal rheostat by a liquid one (platinum in dilute sulphuric acid), the immersed

metal surface being very small. There must be a definite ratio between this surface and the surface of the skin touched by the electrode to produce a cessation of the tone—that is, when the displacement of phase of the electrical vibrations is to be equalized. The graduation of the rheostat is a difficult matter, and it of course is only available for certain strengths of current. From observations of the author, it appears probable that the seat of polarization is mainly, if not exclusively, in the uppermost layers of the skin. —*Beiblätter der Physik*, No. 4, 1892; from *Verhandl. des X. Congr. fur innere Medizin Wiesbaden*, 1891; *Phil. Mag.*

THEORY OF THE EARTH.

By Sir ARCHIBALD GEIKIE.

THE sixty-second meeting of the British Association for the Advancement of Science commenced on August 3, at Edinburgh, when the following address was delivered by Sir Archibald Geikie, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom.

Lingering for a moment over local associations, we shall find, he said, a peculiar appropriateness in the time of this renewed visit of the association to Edinburgh. A hundred years ago a remarkable group of men was discussing here the great problem of the history of the earth. James Hutton, after many years of travel and reflection, had communicated to the Royal Society, of this city, in the year 1785, the first outlines of his famous "Theory of the Earth." Among those with whom he took counsel in the elaboration of his doctrine were Black, the illustrious discoverer of "fixed air" and "latent heat;" Clerk, the sagacious inventor of the system of breaking the enemy's line in naval tactics; Hall, whose fertile ingenuity devised the first system of experiments in illustration of the structure and origin of rocks; and Playfair, through whose sympathetic enthusiasm and literary skill Hutton's views came ultimately to be understood and appreciated by the world at large. With these friends, so well able to comprehend and criticise his efforts to pierce the veil that shrouded the history of this globe, he paced the streets amid which we are now gathered together; with them he sought the craigs and ravines around us, wherein Nature has laid open so many impressive records of her past; with them he sallied forth on those memorable expeditions to distant parts of Scotland, whence he returned laden with treasures from a field of observation which, though now so familiar, was then almost untrodden. The centenary of Hutton's "Theory of the Earth" is an event in the annals of science which seems most fittingly celebrated by a meeting of the British Association in Edinburgh.

HUTTON'S THEORY OF THE EARTH.

It was a fundamental doctrine of Hutton and his school that this globe has not always worn the aspect which it bears at present; that, on the contrary, proofs may everywhere be culled that the land which we now see has been formed out of the wreck of an older land. Among these proofs, the most obvious are supplied by some of the more familiar kinds of rock, which teach us that, though they are now portions of the dry land, they were originally sheets of gravel, sand and mud, which had been worn from the face of long-vanished continents, and after being spread out over the floor of the sea were consolidated into compact stone, and were finally broken up and raised once more to form part of the dry land. This cycle of change involved two great systems of natural processes. On the one hand, men were taught that by the action of running water the materials of the solid land are in a state of continual decay and transport to the ocean. On the other hand, the ocean floor is liable from time to time to be upheaved by some stupendous internal force akin to that which gives rise to the volcano and the earthquake. Hutton further perceived that not only had the consolidated materials been disrupted and elevated, but that masses of molten rock had been thrust upward among them, and had cooled and crystallized in large bodies of granite and other eruptive rocks which form so prominent a feature on the earth's surface. It was a special characteristic of this philosophical system that it sought in the changes now in progress on the earth's surface an explanation of those which occurred in older times. Its founder refused to invent causes or modes of operation, for those with which he was familiar seemed to him adequate to solve the problems with which he attempted to deal. Nowhere was the profoundness of his insight more astonishing than in the clear, definite way in which he proclaimed and reiterated his doctrine that every part of the surface of the continents, from mountain-top to seashore, is continually undergoing decay, and is thus slowly traveling to the sea. He saw that no sooner will the sea floor be elevated into new land than it must necessarily become a prey to this universal and unceasing degradation. He perceived that, as the transport of disintegrated material is carried on chiefly by running water, rivers must slowly dig out for themselves the channels in which they flow, and thus that a system of valleys, radiating from the water-parting of a country, must necessarily result from the descent of the streams from the mountain crests to the sea. He discerned that this ceaseless and widespread decay would eventually lead to the entire demolition of the dry land; but he contended that from time to time this catastrophe is prevented by the operation of the underground forces, whereby new continents are upheaved from the bed of the ocean. And thus in his system a due proportion is maintained between land and water, and the condition of the earth as a habitable globe is preserved. A theory of the earth so simple in outline, so bold in conception, so full of suggestion, and resting on so broad a base of observation and reflection, ought, we might think, to have commanded at once the attention of men of science, even if it did not immediately awaken the interest of the outside world; but as Playfair sorrowfully admitted, it attracted notice only very slowly, and several years elapsed before any one showed himself publicly concerned about it, either as an enemy or a friend. Some of its earliest critics assailed it for what they asserted to be its irreligious tendency—an accusation which Hutton repudiated with much warmth. The sneer leveled by Cowper a few years earlier at all inquiries into the history of the universe was perfectly natural and intelligible from that poet's point of view. There was then a widespread belief that this world came into existence some 6,000 years ago, and that any attempt greatly to increase that antiquity was meant as a blow to the authority of Holy Writ. So far, however, from aiming at the overthrow of orthodox beliefs, Hutton evidently regarded his "Theory" as an important contribution in aid of natural religion. He dwelt with unfeigned pleasure on the multitude of proofs which he was able to accumulate of an orderly design in the operations of Nature, decay and renovation being so nicely balanced as to maintain the habitable condition of the planet. But as he refused to admit the predominance of violent action in terrestrial changes, and on the contrary contended for the efficacy of the quiet, continuous processes which we can even now see at work around us, he was constrained to require an unlimited duration of past time for the production of those revolutions of which he perceived such clear and abundant proofs in the crust of the earth. The general public, however, failed to comprehend that the doctrine of the high antiquity of the globe was not inconsistent with the comparatively recent appearance of man—a distinction which seems so obvious now.

PLAYFAIR'S EXPOSITION OF HUTTON'S THEORY.

Many years might have elapsed before Hutton's teaching met with wide acceptance, had its recognition depended solely on the writings of the philosopher himself. For, despite his firm grasp of general principles, and his mastery of the minutest details, he had acquired a literary style which, it must be admitted, was singularly unattractive. Fortunately for his fame, as well as for the cause of science, his devoted friend and disciple, Playfair, at once set himself to draw up an exposition of Hutton's views. After five years of labor on this task there appeared the classic "Illustrations of the Huttonian Theory," a work which for luminous treatment and graceful diction stands still without a rival in English geological literature. Though professing merely to set forth his friend's doctrines, Playfair's treatise was in many respects an original contribution to science of the highest value. It placed for the first time in the clearest light the whole philosophy of Hutton regarding the history of the earth, and enforced it with a wealth of reasoning and copiousness of illustration which obtained for it a wide appreciation. From long converse with Hutton, and from profound reflection himself, Playfair gained such a comprehension of the whole subject that, discarding the non-essential parts of his master's teaching, he was able to give so lucid and accurate an exposition of the general scheme of Nature's operations on the surface of the globe, that with only slight corrections and expansions his treatise may serve as a textbook to-day. In some respects, indeed, his volume was long in advance of its time. Only, for example, within the present generation has the truth of his teaching in regard to the origin of valleys been generally admitted. Various causes contributed to retard the progress of the Huttonian doctrines. Especially potent was the influence of the teaching of Werner, who, though he perceived that a definite order of sequence could be recognized among the materials of the earth's crust, had formed singularly narrow conceptions of the great processes whereby that crust has been built up. His enthusiasm, however, fired his disciples with the zeal of proselytes, and they spread themselves over Europe to preach everywhere the artificial system which they had learned in Saxony. By a curious fate Edinburgh became one of the great headquarters of Wernerism. The friends and followers of Hutton found themselves attacked in their own city by zealots who, proud of superior mineralogical acquirements, turned their most cherished ideas upside down and assailed them in the uncouth jargon of Freiberg. Inasmuch as subterranean heat had been invoked by Hutton as a force largely instrumental in consolidating and upheaving the ancient sediments that now form so great a part of the dry land, his followers were nicknamed Plutonists. On the other hand, as the agency of water was almost alone admitted by Werner, who believed the rocks of the earth's crust to have been chiefly chemical precipitates from a primeval universal ocean, those who adopted his views received the equally descriptive name of Neptunists. The battle of these two contending schools raged fiercely here for some years, and though mainly from the youth, zeal and energy of Jameson, and the influence which his position as professor in the university gave him, the Wernerian doctrines continued to hold their place, they were eventually abandoned even by Jameson himself, and the debt due to the memory of Hutton and Playfair was tardily acknowledged.

THE NEPTUNISTS AND THE PLUTONISTS.

The pursuits and the quarrels of philosophers have from early times been a favorite subject of merriment to the outside world. Such a feud as that between the Plutonists and Neptunists would be sure to furnish abundant matter for the gratification of this propensity. Among the names of the friends and followers of Hutton there is one which on this occasion deserves to be held in especial honor, that of Sir James Hall, of Dunglass. Having accompanied Hutton in some of his excursions, and having discussed with him the problems presented by the rocks of Scotland, Hall was familiar with the views of his master, and was able to supply him with fresh illustrations of them from different parts of the country. Gifted with remarkable originality and ingenuity, he soon perceived that some of the questions involved in the theory of the earth could probably be solved by direct physical experiment. Hutton, however, mistrusted any attempt "to judge of the great operations of Nature by merely kindling a fire, and looking into the bottom of a little crucible." Out of deference to this prejudice Hall delayed to carry out his intention during Hutton's lifetime. But afterward he instituted a remarkable series of researches which are memorable in the history of science as the first methodical endeavor to test the value of geological speculation by an appeal to actual experiment. The Neptunists, in ridiculing the Huttonian doctrine that basalt and similar rocks had once been molten, asserted that, had such been their origin, these masses would now be found in the condition of glass or slag. Hall, however, triumphantly vindicated his friend's view by proving that basalt could be fused, and thereafter by slow cooling could be made to resume a stony texture. Again, Hutton had asserted that under the vast pressures which must be effective deep within the earth's crust, chemical reactions must be powerfully influenced, and that under such conditions even limestone may conceivably be melted without losing its carbonic acid. Various specious arguments had been adduced against this proposition, but by an ingeniously devised series of experiments Hall succeeded in converting limestone under great pressure into a kind of marble, and even fused it, and found that it then acted vigorously on other rocks. These admirable researches, which laid the foundations of experimental geology, constitute not the least memorable of the services rendered by the Huttonian school to the progress of science.

SMITH'S LAW OF ORGANIC SUCCESSION.

Clear as was the insight and sagacious the inferences of these great masters in regard to the history of the globe, their vision was necessarily limited by the comparatively narrow range of ascertained fact which up to their time had been established. They taught men to recognize that the present world is built of the ruins of an earlier one, and they explained with admirable perspicacity the operation of the processes whereby the degradation and renovation of land are brought about. But they never dreamed that a long and orderly series of such successive destructions and renewals had taken place, and had left their records in the crust of the earth. They never imagined that from these records it would be possible to establish a determinate chronology that could be read everywhere, and applied to the elucidation of the remotest quarter of the globe. It was by the memorable observations and generalizations of William Smith that this vast extension of our knowledge of the past history of the earth became possible. While the Scottish philosophers were building up their theory here, Smith was quietly ascertaining by extended journeys that the stratified rocks of the west of England occur in a definite sequence, and that each well marked group of them can be discriminated from the others, and identified across the country by means of its inclosed organic remains. It is nearly a hundred years since he made known his views, so that by a curious coincidence we may fitly celebrate on this occasion the centenary of William Smith as well as that of James Hutton. No single discovery has ever had a more momentous and far-reaching influence on the progress of a science than that law of organic succession which Smith established. At first it served merely to determine the order of the stratified rocks of England. But it soon proved to possess a world-wide value, for it was found to furnish the key to the structure of the whole stratified crust of the earth. It showed that within that crust lie the chronicles of a long history of plant and animal life upon this planet, it supplied the means of arranging the materials for this history in true chronological sequence, and it thus opened out a magnificent vista through a vast series of ages, each marked by its own distinctive types of organic life, which, in proportion to their antiquity, departed more and more from the aspect of the living world.

THE MODERN SCIENCE OF GEOLOGY.

Thus a hundred years ago, by the brilliant theory of Hutton and the fruitful generalization of Smith, the study of the earth received in our country the impetus which has given birth to the modern science of geology. From the earliest times the natural features of the earth's surface have arrested the attention of mankind. The rugged mountain, the cleft ravine, the scarped cliff, the solitary bowlder, have stimulated curiosity and prompted many a speculation as to their origin. The shells embedded by millions in the solid rocks of hills far removed from the sea have still further pressed home these "obstinate questionings." But for many long centuries the advance of inquiry into such matters was arrested by the paramount influence of orthodox theology. It was not merely that the church opposed itself to the simple and obvious interpretation of these natural phenomena. So implicit had faith become in the accepted views of the earth's age and of the history of creation, that even laymen of intelligence and learning set themselves, unbidden and in perfect good faith, to explain away the difficulties which Nature so persistently raised up, and to reconcile her teachings with those of the theologians. In the various theories thus originating the amount of knowledge of natural law usually stood in inverse ratio to the share played in them by an uncontrolled imagination. The speculations, for example, of Burnet, Whiston, Whitehurst, and others in this country cannot be read now without a smile. In no sense were they scientific researches; they can only be looked upon as exercitations of learned ignorance. Springing mainly out of a laudable desire to promote what was believed to be the cause of true religion, they helped to retard inquiry, and exercised in that respect a baneful influence on intellectual progress. It is the special glory of the Edinburgh school of geology to have cast aside all this fanciful trifling. Hutton boldly proclaimed that it was no part of his philosophy to account for the beginning of things. His concern lay only with the evidence furnished by the earth itself as to its origin. With the intuition of true genius, he early perceived that the only solid basis from which to explore what has taken place in bygone time is a knowledge of what is taking place to-day. He thus founded his system upon a careful study of the processes whereby geological changes are now brought about. He felt assured that Nature must be consistent and uniform in her working, and that only in proportion as her operations at the present time are watched and understood will the ancient history of the earth become intelligible. Thus, in his hands, the investigation of the present became the key to the interpretation of the past. The establishment of this great truth was the first step toward the inauguration of a true science of the earth. The doctrine of the uniformity of causation in Nature became the fruitful principle on which the structure of modern geology could be built up.

UNIFORMITY OF CAUSATION.

Fresh life was now breathed into the study of the earth. A new spirit seemed to animate the advance along every pathway of inquiry. Facts that had long been familiar came to possess a wider and deeper meaning when their connection with each other was

recognized as parts of one great harmonious system of continuous change. In no department of Nature, for example, was this broader vision more remarkably displayed than in that wherein the circulation of water between land and sea plays the most conspicuous part. From the earliest times men had watched the coming of clouds, the fall of rain, the flow of rivers, and had recognized that on this nicely adjusted machinery the beauty and fertility of the land depend. But they now learned that this beauty and fertility involve a continual decay of the terrestrial surface; that the soil is a measure of this decay, and would cease to afford us maintenance were it not continually removed and renewed; that through the ceaseless transport of soil by rivers to the sea the face of the land is slowly lowered in level and carved into mountain and valley, and that the materials thus borne outward to the floor of the ocean are not lost but accumulate there to form rocks, which in the end will be upraised into new lands. Decay and renovation, in well balanced proportions, were thus shown to be the system on which the existence of the earth as a habitable globe had been established. It was impossible to conceive that the economy of the planet could be maintained on any other basis. Without the circulation of water the life of plants and animals would be impossible, and with that circulation the decay of the surface of the land and the renovation of its disintegrated materials are necessarily involved. As it is now, so must it have been in past time. Hutton and Playfair pointed to the stratified rocks of the earth's crust as demonstrations that the same processes which are at work today have been in operation from a remote antiquity.

By thus placing their theory on a basis of actual observation, and providing in the study of existing operations a guide to the interpretation of those in past times, they rescued the investigation of the history of the earth from the speculations of theologians and cosmologists, and established a place for it among the recognized inductive sciences. To the guiding influence of their philosophical system the prodigious strides made by modern geology are in large measure to be attributed. And here in their own city, after the lapse of a hundred years, let us offer to their memory the grateful homage of all who have profited by their labors. But while we recognize with admiration the far-reaching influence of the doctrine of uniformity of causation in the investigation of the history of the earth, we must upon reflection admit that the doctrine has been pushed to an extreme perhaps not contemplated by its original founders. To take the existing conditions of nature as a platform of actual knowledge from which to start in an inquiry into former conditions was logical and prudent. Obviously, however, human experience, in the few centuries during which attention has been turned to such subjects, has been too brief to warrant any dogmatic assumption that the various natural processes must have been carried on in the past with the same energy and at the same rate as they are carried on now. Variations in energy might have been legitimately conceded as possible, though not to be allowed without reasonable proof in their favor. It was right to refuse to admit the operation of speculative causes of change when the phenomena were capable of natural and adequate explanation by reference to causes that can be watched and investigated. But it was an error to take for granted that no other kind of process or influence, nor any variation in the rate of activity save those of which man has had actual cognizance, has played a part in the terrestrial economy. The uniformitarian writers laid themselves open to the charge of maintaining a kind of perpetual motion in the machinery of nature. They could find in the records of the earth's history no evidence of a beginning, no prospect of an end. They saw that many successive renovations and destructions had been effected on the earth's surface, and that this long line of vicissitudes formed a series of which the earliest were lost in antiquity, while the latest were still in progress toward an apparently illimitable future.

PROGRESSION IN ORGANIC TYPES.

The discoveries of William Smith, had they been adequately understood, would have been seen to offer a corrective to this rigidly uniformitarian conception, for they revealed that the crust of the earth contains the long record of an unmistakable order of progression in organic types. They proved that plants and animals have varied widely in successive periods of the earth's history, the present condition of organic life being only the latest phase of a long preceding series, each stage of which recedes further from the existing aspect of things as we trace it backward into the past. And though no relic had yet been found, or indeed was ever likely to be found, of the first living things that appeared upon the earth's surface, the manifest simplification of types in the older formations pointed irresistibly to some beginning from which the long procession had taken its start. If, then, it could thus be demonstrated that there had been upon the globe an orderly march of living forms from the lowliest grades in early times to man himself to-day, and thus that in one department of her domain, extending through the greater portion of the records of the earth's history, nature had not been uniform, but had followed a vast and noble plan of evolution, surely it might have been expected that those who discovered and made known this plan would seek to ascertain whether some analogous physical progression from a definite beginning might not be discernible in the framework of the globe itself. But the early masters of the science labored under two great disadvantages. In the first place, they found the oldest records of the earth's history so broken up and effaced as to be no longer legible. And in the second place, they lived under the spell of that strong reaction against speculation which followed the bitter controversy between the Neptunists and Plutonists in the earlier decades of the century. They considered themselves bound to search for facts, not to build up theories; and as in the crust of the earth they could find no facts which threw any light upon the primeval constitution and subsequent development of our planet, they shut their ears to any theoretical interpretations that might be offered from other departments of science. It was enough for them to maintain, as Hutton had done, that in the visible structure of the earth itself no trace can be found of the beginning of things, and that the oldest terrestrial records reveal no physical conditions essentially different from those in which we still live. They doubtless listened with interest to the speculations of Kant, Laplace, and Herschel, on the probable evolution of nebulæ, suns, and planets; but it was with the languid interest attaching to ideas that lay outside of their own domain of research. They recognized no practical connection between such speculations and the data furnished by the earth itself as to its own history and progress.

THE BEGINNING OF THINGS.

This curious lethargy with respect to theory on the part of men who were popularly regarded as among the most speculative followers of science would probably not have been speedily dispelled by any discovery made within their own field of observation. Even now, after many years of the most diligent research, the first chapters of our planet's history remain undiscovered or undecipherable. On the great terrestrial palimpsest the earliest inscriptions seem to have been hopelessly effaced by those of later ages. But the question of the primeval condition and subsequent history of the planet might be considered from the side of astronomy and physics. And it was by investigations of this nature that the geological torpor was eventually dissipated. To our illustrious former President, Lord Kelvin, who occupied this chair when the association last met in Edinburgh, is mainly due the rousing of attention to this subject. By the most convincing arguments he showed how impossible it was to believe in the extreme doctrine of uniformitarianism. And though, owing to uncertainty in regard to some of the data, wide limits of time were postulated by him, he insisted that within these limits of time the whole evolution of the earth and its inhabitants must have been comprised. While, therefore, the geological doctrine that the present order of nature must be our guide to the interpretation of the past remained as true and fruitful as ever, it had now to be widened by the reception of evidence furnished by a study of the earth as a planetary body. The secular loss of heat, which demonstrably takes place both from the earth and the sun, made it quite certain that the present could not have been the original condition of the system. This diminution of temperature with all its consequences is not a mere matter of speculation, but a physical fact of the present time as much as any of the familiar physical agencies that affect the surface of the globe. It points with unmistakable directness to that beginning of things of which Hutton and his followers could find no sign.

TERRESTRIAL CATASTROPHES.

Another modification or enlargement of the uniformitarian doctrine was brought about by continued investigation of the terrestrial crust and consequent increase of knowledge respecting the history of the earth.

Though Hutton and Playfair believed in periodical catastrophes, and indeed required these to recur in order to renew and preserve the habitable condition of our planet, their successors gradually came to view with repugnance any appeal to abnormal, and especially to violent, manifestations of terrestrial vigor, and even persuaded themselves that such slow and comparatively feeble action as had been witnessed by man could alone be recognized in the evidence from which geological history must be compiled. Well do I remember in my own boyhood what a cardinal article of faith this prepossession had become. We were taught by our great and honored master, Lyell, to believe implicitly in gentle and uniform operations, extended over indefinite periods of time, though possibly some, with the zeal of partisans, carried this belief to an extreme which Lyell himself did not approve. The most stupendous marks of terrestrial disturbance, such as the structure of great mountain chains, were deemed to be more satisfactorily accounted for by slow movements prolonged through indefinite ages than by any sudden convulsion. What the more extreme members of the uniformitarian school failed to perceive was the absence of all evidence that terrestrial catastrophes even on a colossal scale might not be a part of the present economy of this globe. Such occurrences might never seriously affect the whole earth at one time, and might return at such wide intervals that no example of them has yet been chronicled by man. But that they have occurred again and again, and even within comparatively recent geological times, hardly admits of serious doubt. How far at different epochs and in various degrees they may have included the operation of cosmical influences lying wholly outside the planet, and how far they have resulted from movements within the body of the planet itself, must remain for further inquiry. Yet the admission that they have played a part in geological history may be freely made without impairing the real value of the Huttonian doctrine, that in the interpretation of this history our main guide must be a knowledge of the existing processes of terrestrial change.

(To be continued.)

IMPURITIES IN METALS.

PROF. W. C. ROBERTS-AUSTEN read a paper on "The effect of small quantities of foreign matter on the properties of metals" before the chemical section of the British Association on August 8.

Prof. Austen said this question was being revived nowadays. It had been a very important question in the past, and it was the engineer who had to take it up now. They had all seen that marvelous structure, the Forth Bridge. It contained 0·2 per cent. of carbon. If it contained 0·1 per cent. of carbon, more or less, it would have been quite impossible even for Baker to have designed that bridge without most material alterations in its dimensions. It was the exact percentage of 0·2 of carbon which gave the tensile strength to the material. This percentage of carbon raised the tensile strength of iron from 17 to 28 tons per square inch. In tests of the effect of impurities, sometimes one impurity seized hold of another and masked the effect of it. In other cases the added element either broke up or induced a crystalline structure in the metallic mass. The action of impurities was that, first, they so modified the nature of a metal that, if it had been rendered hard by the application of stress, it could not be softened by annealing; second, they might modify the grain or texture of a metal, and according to their nature exert either a useful or a prejudicial influence. In estimating impurities, there was the great difficulty of getting a metal free from all impurities to start with. He next showed that there was an intimate relation between the atomic volume of a metal and its tenacity. In conclusion, he described a method whereby a graphic curve could be traced by the cooling of a molten metal. The sharper the angles of the curve the purer the metal, and an impurity so small as to be indistinguishable by ordinary analysis completely rounded the angles.

NOVA AURIGÆ.*

By Miss AGNES M. CLERKE, London, England.

NOVA AURIGÆ will always be memorable as the first temporary star to the investigation of which chemical methods were applied. Their application, moreover, had a special fitness to the nature of the apparition, since its most noteworthy feature was the spectroscopic display of motion in the line of sight, for the measurement of which photography offers particular advantages. The spectrum of the new star was indeed of an extraordinary nature. It was twofold. It included a long range of vivid lines extending very far into the ultra-violet, each with a dark line attached to its more refrangible side. The entire hydrogen series, from crimson C to the last of its rhythmically disposed associates, were thus doubled, as well as the calcium line K, the sodium D and others. Many more, at the same time, belonging to the crowd of feebler bright lines, so to speak, threw no shadows; while every well marked dark line seemed connected with a bright one. All, however, that could be terrestrially identified proved to be displaced from their normal positions; the bright lines toward the red, their dark companions, to a still greater extent, toward the blue. Evidently, then, two oppositely moving bodies were concerned in producing a compound spectrum, the gaseous section of which testified to a recession from the earth of about 230 miles a second, while the juxtaposed absorption rays crossed the otherwise continuous spectrum of a mass advancing with the exceptional, though not altogether unprecedented, swiftness of 320 miles per second. Thus, a telescopically single star was resolved, by the analysis of its light, into two physically unlike, though chemically similar, components, accomplishing a daily journey of separation extending over close upon fifty millions of miles! Possibly even a good deal more. Spectroscopic estimates of motion are always minimum values. They take into account only that portion of velocity directed along the visual ray. They necessarily neglect the portion directed across it. We are, however, in absolute ignorance as to how much of the speed of *Nova Aurigæ* was thus directed. All that can be said is that the chances are enormously against the whole of it having been measured on the Potsdam and Tulse Hill negatives.

Nova Aurigæ was then really, though not optically, a double star; and there can be no question but that its luminous outburst sprang from its temporary duplicity. The outburst was very sudden. On December 8, 1891, Dr. Max Wolf, of Heidelberg, took a photograph of the sky around *Z Aurigæ*, showing stars to the ninth magnitude, on which the spot subsequently occupied by the *Nova* was blank. Yet it imprinted itself, forty-eight hours later, as a bright star of the fifth magnitude, on a plate exposed at Harvard College; and attained a maximum, similarly recorded, of about 4·5 magnitude, on December 20. But these photographic documents, as every one interested in the subject is aware, were only looked into after the visual discovery of the star by Mr. Anderson, of Edinburgh, on February 1, 1892. All the information collected about its spectrum, and the extraordinary revelations of movement afforded by it, were accordingly of a later date. This was unfortunate. One single determination of the kind in December would have been worth many in February and March. For it was then, presumably, at the time of the stars' abrupt leap upward from obscurity, that they made their nearest approach to each other; and at that critical epoch, the changes in their velocities must have been comparatively rapid. Fifty days later they had, as it were, settled to their stride, and were rushing apart at a rate the variation of which from uniformity fell nearly, if not quite, within the limits of probable error in measurement.

One point, however, seems perfectly clear. Their velocity was hyperbolic. That is to say, it was not all due to the influence of their mutual gravitation. The bodies animated by it were very far from being relatively at rest when they began to fall together. Each, on the contrary, must have possessed a swift motion of its own pursued along a line nearly opposite to or intersecting that of the other. These assertions can be easily justified.

We may fairly assume that the components of *Nova Aurigæ* passed periastron about the time of their greatest brightness, that is, on December 20. They had accordingly been in course of recession from the scene of their close approach for some forty-four days when they began to be spectroscopically observed; their relative speed can then scarcely have fallen short of six hundred miles a second. It kept, at any rate, well up to 550, on February 22—sixty-four days after periastron—when Dr. and Mrs. Huggins took a fine photograph of the spectrum so curiously significant on the point. Nor had it perceptibly slackened a week or more later, judging from the spectrographic determinations at Potsdam. But this high and lasting speed cannot have been parabolic—cannot, in other words, have been the speed due to the simple falling together, from an indefinite distance, of two gravitating bodies. A combined mass *ten thousand* times that of our sun would be inadequate to produce the observed relative velocity of the components of the *Nova;* the mass of ten thousand suns is not an approximate value, but merely a minimum estimate! An elementary calculation shows that no less enormous a power would be required to produce, at the end of sixty-four days' retreat from a grazing encounter, a parabolic velocity of 500 miles a second, diminishing, at the end of seven additional days, to 537 miles a second. Few, however, will be prepared to admit so extrava-

* A paper read before the Astronomical and Physical Society of Toronto, July 12, 1892.

gant a demand in the way of mass; and there seems no alternative but to conclude the orbits of the separating stars to have been hyperbolas. A very large proportion of their movement might, on this view, be original or inherent, and would hence persist irrespectively of the lapse of time; the changing element due to the accelerative force of gravity sinking, by comparison, into insignificance. Moreover, the ascending branches of the hyperbolas traversed may be assumed to have come near coincidence with our line of vision. Otherwise, the measured velocities, extraordinarily high as they were, must have been considerably exceeded by the actual rates; which appears unlikely.

The meeting of the constituents of *Nova Aurigæ* must then have been casual (in our limited apprehension) and unique. It can never, in all time, be repeated. *Nulla vestigia retrorsum* is the inexorable law of hyperbolic traveling. And this is only what we should expect in the case of a temporary star, the distinguishing "note" of which is one solitary outburst. How such outbursts are occasioned is not indeed in all respects clear; yet the circumstances attending them have been rendered perceptibly less enigmatical by the recent apparition. This was certainly due to the mutual action of two cosmical masses, brought for a short time into close contiguity. Not into actual collision; since their motion survived, evidently without material diminution, an upspringing of incandescence which, accordingly, it could not have been spent in producing. Hence the manner of influence exerted has still to be defined and ascertained. Dr. and Mrs. Huggins incline to the view that it was of a tidal nature. And the bodily strains due to the pull upon each other of two voluminous spheroids, swinging round with possibly a bare escape of contact, must certainly have been of extreme intensity, and would be most likely to cause eruptions of heated gases from their interior parts, by which inert photospheric surfaces might be vivified to brief brilliancy. This hypothesis, too, would account, better perhaps than any other, for some of the minor peculiarities noted in the spectrum of the new star. Thus, the frequently multiple character both of the bright and of the dark lines contained in it testified, it was plausibly argued, to the presence of "reversals," such as commonly occur above sunspots. They may be described as the dividing up of wide bright lines by narrow dark ones, or of wide dark lines by fine bright rays; and they would be an almost inevitable accompaniment of enormous outpourings of ignited gases, ensuing upon tidal deformations. These were then presumably concerned—perhaps fundamentally concerned—with the phenomena of the *Nova;* but other causes may also have contributed to their production. The vividness of the transient illumination suggests, for instance, the agency of electricity rather than mere elevation of temperature; and electric forces of great potency can hardly fail to have been generated by the close approach, at high velocities, and violent mutual disturbance, of two more or less sun-like bodies.

Their solar nature was attested by the character of their spectrum. It was in the main that of the solar chromosphere, but displayed through the means of lines of absorption by the member of the pair advancing toward the earth, while the receding mass showed the same lines brilliant by emission. None of the distinctive elements of nebular or cometary light were detected; and an extreme degree of luminous excitement was certified by the strongly marked presence of the entire ultra-violet hydrogen series of rays, besides that of other groups still more refrangible, of unknown origin. The combined spectrum, in fact, rivaled that of Sirius in the extent and proportionate strength of its most refrangible section.

The question is one of much interest as to how far *Nova Aurigæ* might be regarded as a typical "new star." Was it an object so peculiar that reasonings about it could not legitimately be generalized, or were the discoveries it gave rise to capable of extension to other members of its class? There can be very little doubt as to the answer. Although the apparition had a *specific* character of its own, its *generic* character was that of a true *Nova*. Its visibility lasted, it is true, longer than that of any of its congeners in the present century. *Nova Ophiuchi* (1848), T *Coronæ* (1866), and *Nova Cygni* (1876) had each an exceedingly short maximum—to be counted, indeed, rather by hours than by days—while *Nova Aurigæ* did not enter upon its definitive and precipitate decline for nearly three months after its first manifestation. But the Pilgrim Star of 1572, and Kepler's Star of 1604, continued lucid during a year and a half and two years, respectively, and the triple maximum of Anthelm's *Nova* of 1670 stretched over three years; so that the rule of speedy extinction admits of a fairly wide interpretation. Virtually the same range of bright lines seem, moreover, to have been observed in the spectra of the stars of 1866, 1876, and 1892. All three objects may, accordingly, be referred without hesitation to the same category; and all three must have attained brilliancy through the action of analogous causes. Nor can any valid distinction be drawn between these and other new stars, each of which must hence have represented the transitory conjunction of two bodies happening to pass very close by one another as they swiftly pursued their ways through space. But this state of things might not always disclose itself to observation. The velocities of the rushing masses might often escape even the detecting power of the most stringent light analysis. If directed across our line of sight, they would be spectroscopically annulled; if much inclined to it, they would be so much reduced in amount as easily to evade notice. Further, there is no obvious reason why a gaseous should be strictly matched, as in *Nova Aurigæ*, by an absorption spectrum. But even if it were, the two might not be readily, if at all, distinguishable, since they would depend for their separate conspicuousness upon the oppositely displacing effects of rapid motion in the line of sight. It was this pushing apart of lines identical in origin that made the duplication of the spectrum, in the case of the recent star, so remarkable and unmistakable. Had radial movement been absent, the bright and dark series would have coalesced, and neither might have been distinctly perceptible. For in the integrated light, absorption would so nearly neutralize emission as to give the appearance, if not of a perfectly continuous spectrum, at least of one feebly characterized by those secondary bright lines which were uncompensated by dark ones. Thus, the spectrum of *Nova Andromedæ* (1885) was of this kind, and might conceivably have been so produced. The traces of bright lines noted in it might have represented, not the totality of emission, but only the excess of emission over absorption. They stood perhaps for the algebraic sum of many positive and negative quantities. This condition is periodically illustrated by the well known short period variable, *β Lyræ*, the only star yet known to exhibit a compound spectrum like that of *Nova Aurigæ*. It affords evidence, however, as might have been anticipated, not of hyperbolic, but of approximately circular motion. The bright lines, instead of remaining fixed beside the dark ones, shift to and fro, so as to be seen alternately on either side of them, conformably to the period of nearly thirteen days in which *β Lyræ* varies in luster. At intermediate epochs, moreover, when the orbital velocity of the star is tangentially directed, and its spectroscopic effects are consequently reduced to zero, the bright lines tend toward disappearance, overpowered by their dusky companions. In *Nova Aurigæ*, too, a similar effacement of mutually counterbalancing appearances should have marked (had observations then been practicable) the short interval during which its components wheeled round each other, preparatory to entering upon their endless career of separation. From a different point of view, indeed, this effacement would have been permanent. Had the orbit of the *Nova* been tilted up so as to lie nearly square to our line of vision, its spectrum would have borne a comparatively indeterminate character. The separate elements combined in it would have been inextricably confused; neither visual nor chemical methods could have afforded the means of reading its meaning aright.

THE CURRENTS OF THE NORTH ATLANTIC.

By RICHARD BEYNON, F.R.G.S.

THE development of our over-sea trade, especially the transatlantic section of it, has, during the present century, been phenomenal. Oceanic knowledge has, however, quite failed to keep pace with it. It is matter for regret that our information respecting the Atlantic, its currents, ice limits, and the meteorological conditions obtaining in the atmosphere superincumbent to its surface, is far from satisfactory, and greatly behind what the importance of transatlantic commerce leads one to expect.

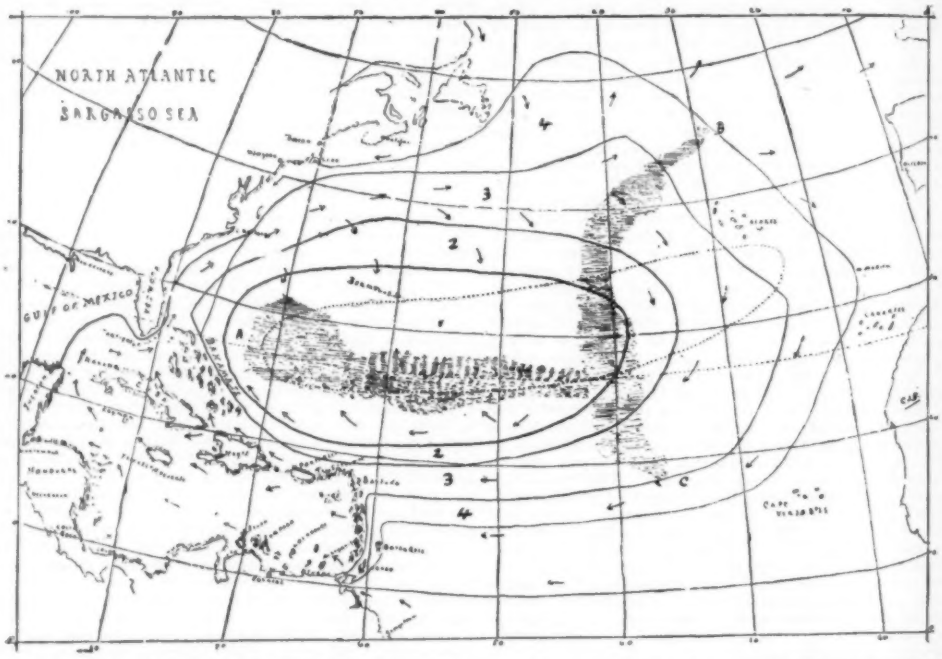
We do not intend, in the present paper, to discuss the theories which best account for the formation of the great equatorial current of the Atlantic, but to deal with the oceanic circulation which lies north of its point of bifurcation off Cape San Roque. In passing, it may be stated that the western drift of the ocean in tropical regions has been known ever since Columbus made his memorable voyages across the Atlantic. That adventurous navigator states: "I regard it as proved that the waters of the sea move from east to west as do the heavens (apparently), *con los ceilos.*"

The progress of the northwesterly moving section of the equatorial current of the Atlantic is so well known that it needs but the briefest allusion. It skirts the shores of Brazil, and then follows the trend of the shores of the Caribbean Sea, and so reaches the most easterly point of Yucatan. Here a division takes place, one part of its waters making the tour of the Gulf of Mexico, while the other section flows along a more direct route by the western extremity of Cuba to Florida, where a reunion takes place and the united current, its impetus increased by northwesterly drifts, the portion of the current which has been entangled among the West Indian Archipelago, flows forth to carry vast stores of heat to the northwest of Europe.

From Florida to Cape Hatteras the shores experience the full benefits of a stream of warm water whose temperature approximates to 80° F., and whose rate of flow is some 70 or 80 miles per day. At this point, however, the eastering influence of the cold water flowing equatorward from the north polar regions begins to be felt, and it is a matter of considerable difficulty to assess the value of this force, or to locate with any degree of accuracy the line along which it is applied. The general direction of the Labrador current and its ramifications was first discovered by Cabot, in 1497, but although many attempts have been made to give an exact position to the line of demarkation between the waters of the Gulf Stream and those of the icy current contiguous to it, our present knowledge of the subject is yet far from being marked by scientific precision.

Navigators report that the Gulf Stream swirls by its antagonistic neighbor with a clearly defined ripple, that on leaving the former current for the latter the transition is rendered perceptible to the sight by the water changing from deep blue to light green, and to the sense of touch by a very marked reduction in the temperature. Scientific research, however, fails to establish the existence of such well marked boundaries, although the fact of Admiral Milne, in the line-of-battle ship Nile, finding a variation of temperature of some 25° between the sea at his stern and at his bow is indisputable. The most reliable index that a vessel is in the vicinity of the meeting of the waters is the partial condensation of the aqueous vapor, for the convergence of two air columns of differing temperatures and humidities often results in dense fogs. But even this hygrometric evidence is not absolutely reliable as revealing the exact *locale* of the dividing line. The variations of the antitrades are frequently the cause of the interposition of air columns from the Gulf Stream between the atmospheric masses superincumbent to the Labrador current. The eastern side of Newfoundland has its mean annual temperature raised considerably by its proximity to the warm current, while Nova Scotia benefits in a lesser but still marked degree. Halifax harbor is never blocked by field ice, and the formation of sheet ice in the harbor itself never obstructs the navigation of steamships. The mean temperature for the month of May averages 44° or 45° F.

Somewhere between the latitude of Cape Cod and that of Newfoundland, the Gulf current undergoes the process of division. One section flows to the northeast



Explanation of Sketch Showing the North Atlantic Sargasso.—The arrows indicate the direction of the currents. The areas marked 1, 2, 3, 4 show the accumulation of different quantities of sargasso. Fig. 1 marks the area of greatest density. The minimum of frequency is encountered in the zone numbered 4, while beyond that area weed accumulation is hardly ever noticeable. The shaded coast line signifies the presence of a weed there identical with the weeds occurrent in the Sargasso Sea. In fact, the shaded coasts are the strips of littoral from which the sargasso weed is detached. The dotted ellipse signifies the area of frequent calms. The shaded portion of the North Atlantic, marked A, B, C, marks the limits of the Sargasso Sea as laid down by Humboldt.

toward northern Europe, while the other pursues an easterly direction, which gradually becomes southeast and then almost due south.

It will be readily seen that the difficulty of obtaining accurate information relative to the direction and speed of ocean currents is very great, and that it is only by many observations extended over a number of years that sufficient data can be procured to generalize from. The Hydrographical Department of the United States has conferred lasting benefits upon Atlantic navigators by their efforts in this direction, and not the least valuable of their contributions to North Atlantic lore is the determination, with approximate exactitude, of its currents and drifts.

The general character of the drifts has been long known. Drifted matter from the New World has been found cast upon the shores of the Old since the days of Columbus. The most remarkable drift on record is that effected by the ship W. L. White. This vessel, an American schooner, was abandoned off Delaware Bay during the terrible snowstorm of 13th March, 1888. She drifted across the Atlantic, assisted doubtless by wind as well as set of current, and finally stranded, after a voyage of 5,000 miles, upon one of the outer Hebrides. From March 13, 1888, to January 23, 1889, was the time occupied on this drift. About 1760 A.D., an English man-of-war was wrecked near St. Domingo, and her mainmast was afterward found stranded on the shores of the Pentland Firth.

Such instances as these, however interesting they may be, afford but little *detail* of the set of the ocean currents. These details a bottle chart issued by the United States marine authorities supplies to a very material extent. The plan adopted is the throwing overboard of bottles in which is a record of the ship's name, latitude and longitude, and date. Of course the co-operation of the masters of the merchant vessels trading to the United States is necessary. The number of bottles which are traced bears but a small proportion to the numbers thrown overboard, but still they are sufficient to enable pretty accurate courses to be assigned for the ocean currents. Seventy-five bot-

tic tracks are laid down on the chart published by the Hydrographic Office at Washington, and an examination of those which are laid down on the accompanying sketch map will reveal at a glance the system of oceanic circulation in the North Atlantic.

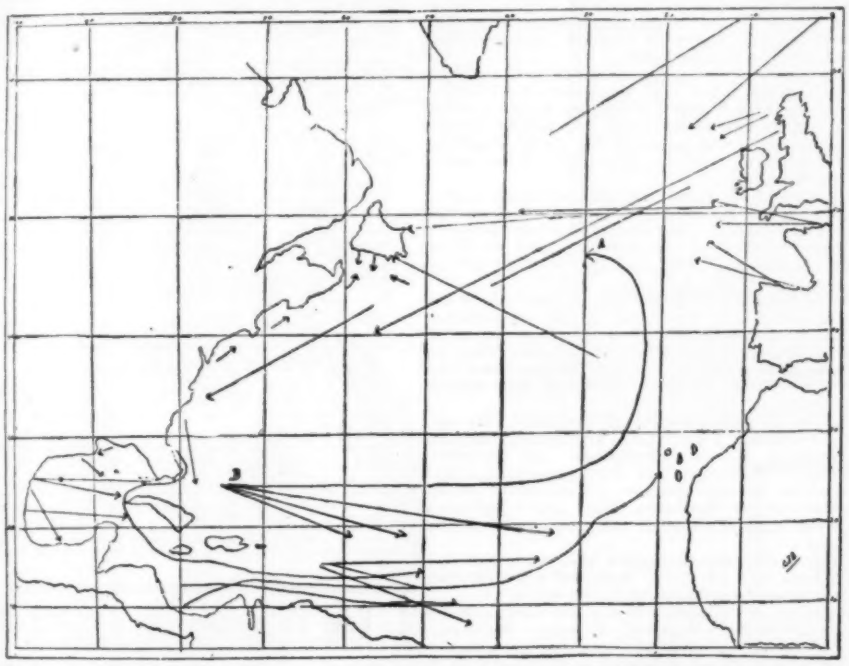
The indraught into Gulf of Mexico is clearly indicated, as also is the drift of the icy Arctic current, which flows equatorward along a course lying to the westward of that followed by the Gulf Stream. The track of the Gulf Stream from Newfoundland is almost coincident with the fiftieth parallel of latitude. Looking at the eastern portion of the chart, it will be seen that the existence of a powerful indraught from the northwest into the Bay of Biscay and its inclosing shores is clearly demonstrated. It is the failure to recognize aright the influence of this current during the prevalence of southwesterly winds that has led to so many ships being cast ashore in the vicinity of Cape Finisterre. Of these disasters, that of H.M.S. Serpent was the most terrible, but the current is a veritable danger trap to shipmasters given to corner shaving, as the records of wreck inquiry courts show but too plainly.

The bottle chart shows an elliptical area of ocean water whose principal axis lies along the thirtieth parallel of latitude, and this area is identical with the Sargasso Sea. From the incipience of transatlantic voyaging down to the past few years, our knowledge of this sea has remained almost stationary. Columbus discovered it, and commented upon it, and the nautical world has since been content with his description, and has added but little to it. He reported pretty fully upon the *praderias de yerva*, or seaweed meadows, which the Santa Maria encountered, and subsequent navigators contented themselves with corroborating his statements, or striving to gain a reputation as ocean explorers by attributing fresh wonders to the region of Sargasso. The principle underlying the accumulation of such quantities of weed as are met with is a very simple one. To quote the words of Humboldt, "The waters of the Atlantic between the parallels of 11° and 43° are carried round in a continual whirlpool." Such being the case, driftweed must of necessity accumulate within the area of the whirl inclosed by the circle of oceanic currents. Finality, as regards knowledge of the Sargasso or weedy sea of the North Atlantic, is yet far from attainment, but much reliable information has been obtained of late years by the researches of German scientists. The captains of the German mercantile marine have been pressed into the service as observers, and the famous Plankton expedition has also contributed its quota to swell the stock of reliable information relative to this Sargasso Sea. The ancient belief relative to it was that it was a "muddy, coagulated, dense sea, covered with weed, which prevented the advance of a ship." Columbus nowhere affirmed that the weed materially interfered with the navigation of his vessel. Oveido, however, does, and in the hands of subsequent writers the density of the the Sargasso increases until it becomes a dense mass, an effective barrier to the passage of ships. This idea is, however, long exploded, and the Sargasso Sea of today is simply an area of comparative calm, into which drifts the weed detached by the currents from the shallows over which they flow. This seaweed drift is densest between 70° and 40° west longitude and 20° and 35° north latitude, where the Sargasso may be said to cover the surface of the sea to an extent varying from 10 to 25 per cent. Outside this ellipse is a region where the Sargasso is less abundantly distributed, and outside that again a zone marked by the presence of still less floating weed, until to the north of the fiftieth parallel of latitude the weed ceases to be found. It is remarkable that the main axis of the Sargasso proper is identical with that of the region of summer calms, with the exception that the latter is continued farther to the eastward. The sources from which the Sargasso weed is derived have always been a vexed question, but the researches of Dr. O. Krummel, of Berlin, have brought the solution within a more appreciable distance than it has ever been before. The Plankton expedition of 1889 threw much light on the matter.

The main supplies of the *Fucus natans* of Linnæus are now pretty accurately determined. The science of sea botany has discovered that a portion of the Sargasso weed comes from the shores of the Caribbean Sea and the West Indian Islands. Other supplies are torn from the confines of the Gulf of Mexico, while some of the weed found floating in mid-Atlantic has been identified with species attached to the shores of the north of Brazil. That the eastern shores of America produced the weed of the Sargasso Sea was long doubted. Columbus, it is said, was afraid lest the weed should mask some sunken rock, upon which his ships might strike. Others maintained that the "social weed" grew at the bed of the sea, even where the ocean was deep, and that after fructification it easily became detached from the rocks and rose to the surface. The experiments of Bouguers relative to the intensity of the light, which penetrated to a depth of 200 ft. below the sea surface, were held to dispose of this theory, because the absence of sunlight in the depths of the sea was held incompatible with the existence of any but *bleached* vegetation. The species of marine weed known as *Laminaria pyrifera* has frequently been found to possess a stem over 850 ft. in length.

The amount of weed discernible in any part of the North Atlantic varies with the season. Northward from 45° the scattered weed is only encountered in the late summer and autumn, while it fails completely in the spring. The further we go to the south the greater is the mean annual quantity of weed observed, and the increase is pretty equally divided between the seasons. Near 30° north the maximum of weed is encountered in the winter, while to the southward of 25° the densest season is spring. These facts prove pretty conclusively that the Sargasso floats in summer time from the current of the Gulf Stream in a southeasterly direction. The rate which this drifting weed assumes in traveling along the convolutions of its course, until it becomes merged in the region of densest Sargasso, varies considerably according to its distance from the coast of Florida. Supposing a bunch of weeds were detached, say, from the Bahama Reef, it would require a fortnight in which to make the journey to Cape Hatteras. The next portion of its voyage—northeast to the sixtieth degree of west longitude—would be accomplished at about half the speed, and would occupy a month to perform. From 60° west to 40° west the speed would have fallen to half a knot per hour, and the 950 knots would take ten or eleven weeks to traverse. From this point there are approximately 600 knots to be covered by the now heavy and saturated weed before the south of the Azores is reached. The weed now moves at the rate of seven or eight miles per day. When this point is reached the weed moves still more sluggishly, and gradually becomes merged in the dense Sargasso, where its only motion is an undulatory one, produced by the motions of the Atlantic swell. How long the floating weed encountered in the center of the Sargasso Sea remains upon the surface is not known, but much of it when it takes up its position there is extremely waterlogged, and soon sinks to the bed of the sea, to make room for fresh supplies of fucus.

Such is a brief summary of our present knowledge of the current system of the North Atlantic. It is far from perfect, and will probably continue to be so until the observing powers of the average British shipmaster are more scientifically developed than they are at present.—*Knowledge.*



Explanation of Sketch Showing Bottle Drifts.—The arrow heads show the spot where the bottle was thrown overboard. Consequently, the line of drift followed will be from the arrow head to the other unmarked end of the line. In drawing the drift lines some attention has been paid to already obtained knowledge relative to their direction, for it is not always correct to assume that the drifting object moves in a straight line from the commencement of its voyage to where it is picked up. This is most noticeable in the drift marked A, B, the bottle following a course almost identical with the eastern and southern boundaries of the Sargasso Sea.

STERILIZED MILK.*

By Dr. ALBERT R. LEEDS and Prof. H. W. CONN.

IT is becoming somewhat doubtful whether the hygienic effects of sterilized milk are all that could be desired or have been claimed. It must not be supposed that the use of sterilized milk has been so widely recommended by physicians without some adequate reason. At first there seemed to be not a little evidence pointing in the direction of a superior hygienic value of sterilized milk. From the beginning it was recognized that the sterilization of milk by high heat changed its chemical nature to a certain extent, but the change was thought to be slight and rather in the direction of improving its food value than otherwise. Munk, for instance (*Deutsch. Med. Woch.*, 1881), found that rennet would act differently upon sterilized milk from what it would on raw milk. In the latter it precipitates the casein in masses, while in the sterilized milk the casein is precipitated in fine flakes, and this method of casein curdling was said to be much more like that of the action of rennet on human milk. Munk, therefore, thought that sterilizing actually rendered cow's milk more like human milk, and hence its increased value. These conclusions were deduced from experiments in artificial digestion, and also from digestion of such milk by dogs. Similar results were obtained by others, some experimenters actually claiming that sterilized milk was more easily digested and more readily absorbed by the body. . . .

In our cities to-day, one of the first directions given to nurses of infants suffering from intestinal complaints is to sterilize their milk, and the general consensus of opinion seems to be that these troubles yield most readily to the new diet. In Europe there is probably even more of a tendency in this direction than in this country. There seems to be a very general opinion among those interested in the matter in Germany that sterilized milk has a very decided value in hygiene. In some places this opinion is so firmly fixed that plants have been established for the sterilization of milk on a large scale for supplying a city. . . .

It is, in short, so general a belief that sterilization is a desirable process that it requires considerable courage to venture to suggest that perhaps we may be on the wrong track in trying to solve the milk problem in this way. Nevertheless, it is becoming very evident that the matter requires more study. For infant feeding, as we have seen, it is especially desirable that the bacteria in milk should be destroyed, since the child's digestive organs are more sensitive to such disturbing influences than are the digestive organs of adults. For this reason sterilization is very widely recommended for infants, though not regarded as so necessary for adults. But it is plain that for the very same reason the milk given to infants should be as nearly like the natural condition as possible. For the same reason that we do not want bacteria in the milk of infants, we do not want the chemical nature of that milk very much different from that of natural milk. Now we are beginning to learn that the chemical changes which occur in milk, as the result of sterilization, are much more profound than was at first supposed. Sterilization by heat, under pressure, of a temperature of above 100° C. certainly so changes the character of the milk that it can no longer be regarded as the same product which was furnished by nature. The chief changes which are now known to occur may be comprised under the following heads:

Destruction of the Germicidal Power.—It has been discovered recently that fresh milk has some considerable power as a germicide. This is certainly a remarkable discovery, but it appears to be unquestionable. Careful experiments have shown that several species of the pathogenic bacteria are actually destroyed by the effect of fresh milk. If a known number of cholera germs be put in fresh milk, there will be found to be a smaller number present after three hours than at first. We do not yet know what this germicidal power in milk means, and it is almost too early to speculate upon its value. It would seem that it may be one of the safeguards supplied by nature against disease. If we can look upon it as such, we must regard anything which destroys this power as injurious to the milk. Now, heating the milk rapidly destroys its germicidal power. To be sure that germicidal power disappears of itself after a few hours, and it is not safe, therefore, to insist too strongly upon any injury in this direction which may result from sterilization. But the sterilization of fresh milk certainly will destroy this property; and this, so far as it goes, must be regarded as undesirable.

A second effect of sterilization is the coagulation of the *albumen* of the milk. This albumen, called lactalbumen, is a very close ally of serum albumen of the blood. By heat it is in part coagulated, and the milk is thereby rendered more viscous. In this way a soluble albumen is rendered insoluble and seemingly more difficult of digestion. It would appear probable, also, that it is the coagulation of the albumen which is the cause of the taste appearing in boiled milk.

A third effect of the heat is the destruction of the *starch-fermenting power* possessed by raw milk. The saliva of the adult possesses a ferment which converts starch into sugar, but this active element is absent from the saliva of the infant. It is a striking fact to find, therefore, that fresh milk possesses a somewhat similar ferment. It has been called galactozymose, and is of a proteid nature, easily affected by heat. There can be but little doubt that the presence of this starch-liquefying ferment is an important factor in the value of milk as a food for the infant, whatever may be said of its value to the adult. Now, it has been found by one of the authors of this paper (*Amer. Journ. Med. Sci.*, 1891) that a heat of 75° C. (165° F.) destroys this ferment entirely. Sterilized milk, therefore, will be with certainty deprived of this natural starch-liquefying ferment.

Upon the *milk sugar* the high heat has also a profound effect. Long-continued heating completely destroys the sugar. Even in the ordinary sterilization under pressure it seems that the sugar is much changed. The milk turns brown, and this has been attributed to a caramelization of the milk sugar. The same browning of the milk will not infrequently occur in sterilizing milk by a simple steaming without pressure. Duclaux has stated that this browning is due to an effect on the albumen rather than on the milk sugar. But at all events it is certain that a high heat will destroy the sugar.

Upon the *fat* of milk the sterilization has also a marked effect. Fat exists in the milk in a state of finely divided particles, forming an emulsion. The fat is sometimes found to collect in drops on the surface of the sterilized milk, and when this occurs, of course, the emulsion is destroyed. Now, the fat of the food must be in a state of emulsion before it can be absorbed from the intestines. In raw milk the emulsion is already formed, and thus the digestive organs are relieved from their share of their duty. It can hardly be questioned that the destruction of this emulsion

* From a report to the Dairy Commission of the State of New Jersey on "The Preservation of Milk."

will render the digestion of the milk more difficult or its absorption less complete.

Lastly, the sterilization has some effect upon the *casein*. We are unable at present to determine what this effect is, but as a result we find that it is less easily and less completely precipitated by rennet. According to Baginsky it requires a larger amount of rennet and a higher temperature to precipitate the casein of sterilized milk. According to Soxhlet the casein can only be precipitated from boiled milk after the addition of calcium salts. According to the authors, the casein of such milk is less readily precipitated both at a low and a high temperature, and the precipitation is less complete. Moreover, we find, by experiments in artificial digestion, that the casein of sterilized milk is less readily acted upon by pepsin and pancreatin, and therefore probably less easily digested.

The chemical changes above mentioned occur in milk which is sterilized under pressure, and hence at a heat above boiling, but almost exactly the same occurs when milk is sterilized at a boiling temperature. Under ordinary steaming in the common forms of apparatus there is not so much of a change in the milk sugar, unless continued for a long time, and possibly the effect on the casein is slightly less. But all the other effects of high heat are equally well marked at a temperature of 100° C., and we can therefore not regard the sterilization of milk by steam as in any marked respect superior to its sterilization under pressure.

It is certain that these chemical changes are very great and much more important than was believed when sterilized milk was first recommended and first used. Such milk is certainly not a natural product any longer. It is not the food which nature has supplied, but an artificial product, of human invention. It is no longer dangerous from its bacterial contents, but it is not *milk*. Is such a product desirable as a food? Upon the answer to this question must depend the future of the process of milk sterilization.

A WORLD POST.

IN the *Gazette* of Aug. 15 appeared a Treasury warrant regulating the postal relations of this country with the rest of the world, and taking effect as from the 1st of July last. Until recently such a reform would have been an impossibility. The Postal Union, indeed, which has been established many years, brought with it uniformity of rate and conditions over a wide area. But large and important countries, notably some of our own colonies, long remained outside the union, or entered it only on terms which allowed them to maintain differential rates. A few years since not even the best informed expert could have given a list of foreign and colonial rates of postage without some consideration; and the list would certainly have been a long one. So complicated, indeed, were our international postal relations that they were set forth in more than 250 sets of regulations and warrants, the long list of which is appended, for the purpose of repeal, to the new document. Within recent years uniformity and simplicity have gradually taken the place of multifariousness and complexity, and the warrant now issued is the result of the change. The rates of postage from these coasts to all other parts are now so few that they can be told upon the fingers.

The conditions of transit are governed by intelligible principles, applicable with but slight modifications throughout the world. A letter may now be sent from the United Kingdom to any colony or foreign country at the rate of 2½d. for every half ounce in weight. A postcard, which is, in fact, an open letter, may be forwarded in like manner for a penny. And a packet of papers, whether printed or written, not containing anything in the nature of personal correspondence, may be transmitted to the most distant place at the rate of a halfpenny for every two ounces—our own inland book-post rate. The same rate applies to packets of samples or patterns. Thus we may say that there is a uniform rate for the open packet post—one halfpenny per two ounces. One difference only is observed between the several kinds of packets; for printed papers the *minimum* postage is the initial rate of a halfpenny, for written papers one penny, and for a sample packet 2½d.

Turning now to the conditions of transit, it is a universal rule that postage must be prepaid. In the case of a letter, however, disregard of the rule involves only a fine of double the postage on delivery; while open packets, if posted without any stamp, will be detained and returned to the senders. Of course, every packet, other than a closed letter, is liable to examination in the post, and nothing dangerous or offensive may be forwarded; it is also unlawful to send any article liable to customs duty, for the obvious reason that no machinery exists for collecting such duties, except in connection with the parcel post. A foreign letter may be of any weight, but must not exceed two ft. in length, or one ft. in breadth or depth. The same dimensions apply to a packet of written or printed papers, unless sent in the form of a roll, when it may be 30 in. long and 4 in. in diameter; but such a packet must not weigh more than 12 oz. The limits of a sample packet are somewhat more restricted, but, on the other hand, it may weigh as much as 12 oz.

It is more interesting, however, to note the several postal facilities beyond mere transmission which the public enjoy throughout the world. Any kind of postal packet may be registered for the sum of 2d.; and underwriters will testify that the registered post is the safest means of conveyance they know. The sender of any registered postal packet may, upon paying an additional fee of 2½d., obtain an acknowledgment of the delivery of the packet to the addressee. Any packet, again, which has once paid international postage may be redirected from the first to any other address free of charge; and any packet may be expedited in its course by the payment of an express fee for special delivery, such fee being under the postal convention 3d., when the place of address is near the post office.

Of course it need hardly be said that the simple rules thus laid down are liable to some modification, to meet the inland postal regulations of the country of address. Some countries may have no machinery for obtaining an acknowledgment of the delivery of a letter, or for handing it to the addressee by a special messenger; it is but very recently that either service has been performed in this country. Registration may not be everywhere very clearly understood; in some parts of South Africa there may even be some haziness as to the distinction between a letter and a postcard. Again, a letter addressed to the interior of China must take its chance after it has left the Treaty Ports, and there may be something to pay for its ultimate delivery. This country can only in such cases take any missive intrusted to it subject to all risks. But speaking broadly, the rules which now govern the post (other than parcel post) throughout the civilized world are now reduced to uniformity and will be found laid down in comparatively few words in the warrant just issued at the instance of Sir James Fergusson. Of the newer parcel post so much cannot be said. This country is not a party to the general postal convention on the subject, and the rates and conditions of transit are regulated by treaties framed with each country. The more bulky the package conveyed, the more difficult, no doubt, to establish uniform rates. But we may hope that before long something may be done to simplify this post also, and to establish for the tables of rates and dimensions, which at present occupy twelve pages of the Postal Guide, a few generally applicable rates and principles.—*London Times*.

THE SCIENTIFIC AMERICAN

Architects and Builders Edition

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Cyclopedia of Receipts,

NOTES AND QUERIES.

680 PAGES. PRICE $5.

This splendid work contains a careful compilation of the most useful Receipts and Replies given in the Notes and Queries of correspondents as published in the SCIENTIFIC AMERICAN during nearly half a century past; together with many valuable and important additions.

Over Twelve Thousand selected receipts are here collected; nearly every branch of the useful arts being represented. It is by far the most comprehensive volume of the kind ever placed before the public.

The work may be regarded as the product of the studies and practical experience of the ablest chemists and workers in all parts of the world; the information given being of the highest value, arranged and condensed in concise form, convenient for ready use.

Almost every inquiry that can be thought of, relating to formulæ used in the various manufacturing industries, will here be found answered.

Instructions for working many different processes in the arts are given. How to make and prepare many different articles and goods are set forth.

Those who are engaged in any branch of industry probably will find in this book much that is of practical value in their respective callings.

Those who are in search of independent business or employment, relating to the manufacture and sale of useful articles, will find in it hundreds of most excellent suggestions.

MUNN & CO., Publishers,
361 Broadway, New York.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASSAYING.—An Improved Method of Determining Small Percentages of Silver and Gold in Base Metals, Mattes, etc.—By CALEB WHITEHEAD.—An exact method of assay in the cases mentioned described, with results as attained in actual practice, weights of substances used, and general details of the process.... 13937

II. ASTRONOMY.—Nova Aurigæ.—By Miss AGNES M. CLERKE.—The wonderful discoveries made in the case of the temporary star Nova Aurigæ.—The first one spectroscopically investigated.—How it was found to be a double star.... 13939

III. BIOLOGY.—The Science of Fishes.—By J. S. KINGSLEY.—The biological laboratory at Wood's Holl and what is to be seen in it.—The work of students and the methods of instruction and investigation employed.... 13940

IV. CIVIL ENGINEERING.—Underpinning by Means of Grouting and Stock Ramming.—By WALTER ROBERT KNIPPLE.—Methods of securing foundations which threaten to settle by deposition of thin mortar beneath them and the ramming of hard material into the soft substratum.—5 illustrations.... 13940

V. ELECTRICITY.—Electrical Resistance of the Human Body.—By M. VON FREY.—The resistance of the human body measured as an electrolyte, showing the importance of large electrodes in securing the lowest resistance.... 13940

Frictional and Galvanic Electricity.—The modern view of electricity and the abandonment of the old distinctions between the two old-time divisions mentioned.... 13937

VI. GEOLOGY.—The Theory of the Earth.—By Sir ARCHIBALD GEIKIE.... 13940

VII. HYDROGRAPHY.—The Currents of the North Atlantic.—By RICHARD BEYNON.—Investigation of the currents of the ocean by bottles.—A map showing bottle drifts, illustrating the location of the Sargasso Sea.—Map of the Sargasso Sea.—2 illustrations.... 13940

VIII. HYGIENE.—Sterilized Milk.—By Dr. ALBERT R. LEEDS and Prof. H. W. CONN.—The effects of sterilization on milk, with but as well as good effects produced upon milk by heating.... 13941

IX. METALLURGY.—Impurities in Metals.—By Prof. W. C. ROBERTS-AUSTEN.... 13938

X. MISCELLANEOUS.—The Captain of the Mary Rose.—A companion piece to the famous battle of Dorking, an imaginary naval battle between France and England, indicating the possibilities of the search light.—5 illustrations.... 13937

Tunny Fishing on the Mediterranean.—How the fish are watched for from watch towers and how they are caught, an interesting account of the characteristic industry.—1 illustration.... 13941

The Kola Nut.... 13941

Whaling in the North.—The new methods of catching whale with steam vessels and harpoons fired from guns.—The sport as witnessed by the Emperor William of Germany.—9 illustrations.... 13938

XI. POLITICAL ECONOMY.—A World Post.—The postal union and the gradual reduction to uniformity of postal rates and methods throughout the world.... 13942

XII. TECHNOLOGY.—Manufacture of Paper on the Continent.—The manufacture of paper in modern days from wood pulp, rags and other material, a popular account of the modern development of the industry.—2 illustrations.... 13935

Ruscher's Process of Sugar Crystallization.—An attempt to accelerate the crystallization of sugar in order to avoid as much as possible the production of molasses and the consequent lowered yield of crystallizable sugar.... 13941

What is the Cause of Paint Peeling on Outside Work?—A very valuable practical discussion by house painters.—Why it is that paint on houses peels.—Probabilities of water being the cause of the trouble.... 13941

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of authors. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.

, 1892.

ment.

ear.

ers in any
x dollars a

T, from the
ad. Price,

T can like-
ed yearly,
er, or $3.00

FIC AMERI-
N SUPPLE-

gents, and

rk, N. Y.

PAGE
nall Per-
etc.—By
the cases
practice,
rocess.... 1337
LEHKE.—
ordinary star
ed.—How
1339
EY.—The
en in K.—
d investi-
1341
Grouting
Methods
osition of
erial into
1343
ody.—By
asured as
des in so-
1347
of elec-
ween the
1347
CHIBALD
1349
ntic.—By
he ocean
location
tions.... 1349
EEDS and
with bad
1351
C. HOB-
1353
A com-
ry naval
ilities of
1357
watched
eresting
1359
1361
g whale
sport as
rations.. 1362
ation and
methods
1363
af.—The
rags and
ment of
1365
t to ac-
he much
ent low-
1366
A very
t in that
ause of
1366

Papers
PLEMENT
ge to any
w York.

ooks
Engineers,
ofessional
e of their
t permits
s at very
ful books
rent sub-
culation,
fied with
ave only
ddress
w York.

S!
h the pub-
to examine
Patents for
ericas, and
Drawings,
ents in the
& Co. also
ks, Labels,
atents. All
aptness, on
full infor-
concerning
ringements.
etc.
aws, show-
al countries
Building,